UNIVERSITY OF PENNSYLVANIA

ACHIEVEMENT TESTS IN BIOLOGY FOR SECONDARY SCHOOL USE BASED UPON AN ANALYSIS OF THE CONTENT OF THE SUBJECT

JOHN M. PRESSON

A THESIS

IN EDUCATION

PRESENTED TO THE FACULTY OF THE GRADUATE SCHOOL IN
PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR
THE DEGREE OF DOCTOR OF PHILOSOPHY

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DIAGRAM

1

Emphasis placed upon various topics of biology in textbooks, teachers' final examination questions, College Entrance Examination Board questions, and Board of Regents questions, inserted between pages 46, 47

I

INTRODUCTION

Since Rice[1] made his test in spelling in 1895, much progress in the construction, use, and interpretation of tests has been accomplished. Workers in the field of tests and measurements have not been content with the mere construction of objective tests, but they have concerned themselves increasingly with the validity and reliability of their tests. In fact, the question as to whether the tests now extant really do measure those things for which they were devised is one of the most pressing problems of workers in the field at the present time.

The purpose of this study is to construct standardized achievement tests in the field of secondary school biology as a result of a careful analysis of the subject matter that is taught in the tenth grade or second year of senior high schools. In this way, the *validity* of the content of the tests will be established in that the tests are intended to measure subject matter of biology taught in these schools.

Data will be presented representing schools in cities of three classes based upon population, namely, 100,000 and over, 25,000 to 100,000, and less than 25,000 including rural communities. Large city, medium-sized city, and small city high schools are terms used throughout this study to designate these types. It should be noted that a rural high school is one located in a town, borough, or village of less than 10,000 population.

In this study, an attempt will be made to collect all data possible concerning the general plan of organization of biological material, the content of subject matter, and the arrangement of the major topics. A detailed study will be made (1) of the biology textbooks in most common use in the secondary schools (2) of state and city courses of study (3) of questions asked by the College Entrance Examination Board, 1916-1926 (4)

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[1] Rice, J. M., *The Futility of the Spelling Grind.* Forum, vol. XXIII, pp. 163–172; 409–419, 1897.

of lists of questions prepared by the Board of Regents for the State of New York during the period from 1916-1926 and (5) of final examination questions given to their classes by one hundred forty-three teachers of biology during the school year 1925-26. The data obtained from these sources are carefully tabulated and analyzed, and are used in the selection of the test-items. The State and city courses of study are used to show the plan of organization of biology work and the content of subject matter. The questions of the College Entrance Examination Board and of the Board of Regents indicate the material considered most important by the examiners. The textbooks are analyzed because they influence the content of instruction and the method of presentation. Teachers' questions are utilized as an index to the subject matter of biology which has been presented by teachers through instruction.

In agreement with the analyses which follow of the sources listed above, the divisions of the subject matter are four, namely, plant, animal, and human biology, and miscellaneous material. Each of these main divisions is sub-divided into a number of major topics commonly accepted by writers of biology textbooks. For example, in plant biology, there are seventeen topics such as seeds, stems, and fruits.

Separate tests have been devised for (1) plant biology and (2) animal and human biology, in each of which is included related miscellaneous material. There are two equivalent forms for each test. The tests are so constructed that the work done in either plant biology or in animal and human biology can be measured at the end of a semester, no matter which is taken first.

In devising the original list of items for the tests, the attempt was made to measure content that was found by this investigation to exist in standard textbooks, examination questions, and courses of study; to test for certain important and fundamental principles of biology; and to provide such a range of questions as to be representative of the whole field of secondary school biology. An effort was made to confine the tests to such dimensions that every exercise could be attempted by the pupils in a period of forty-five minutes.

The steps in the study have been:

1. Analysis of the construction of typical tests and scales in various secondary school subjects in the light of the theories and principles set forth by authorities in the field.

2. Analysis of tests and scales in the field of secondary school biology with especial attention to the critical reviews covering the outstanding qualities and limitations of these tests and scales.

3. As a result of the preceding investigations, the writer set out to build tests in biology with a view to establishing their *validity* and later their *reliability* in a more intensive and thorough way than has been accomplished, in so far as it has been possible to determine, up to this time. To accomplish this end, the following specific steps were followed in this study:

a. Analysis of data received from state departments of education, public secondary school principals, and biology teachers.
b. Analysis of biology textbooks in most general use in the public secondary schools.
c. Analysis of teachers' final examination questions.
d. Analysis of questions of the College Entrance Examination Board and of the Board of Regents for the State of New York.
e. The composition of a large number of test-items to represent the field of biology.
f. Evaluation of test-items by biology teachers.
g. Experimental try-out of items for pupil reaction.
h. The selection of test-items for the second try-out.
i. Second try-out of the tests.
j. The selection of test-items for the final tests.
k. The establishment of tentative standards.

It follows from the sources and the type of study that the methods used in general are analytical, experimental, and statistical.

The material for these tests was assembled during the school year of 1925-26. This information was supplied by state departments of education, secondary school principals, and biology teachers. Specific data were secured from textbooks, examination questions, and state and city courses of study. The pre-

liminary testing was done at the end of the spring term of 1926. The final tests were constructed and the standardization was effected at the end of the second term in January 1929.

Studies available concerning the analyses of the content of biology and the formulation of tests have been examined and have been utilized as a background for the plan of the analysis of content and the formulation of tests in this investigation.[2] The available tests and scales in the field of biology are as follows:

1. Grier,[3] N. M., Range of Information Test in Biology. I Physiology
2. Grier,[4] N. M., Range of Information Test in Biology. II Zoology.
3. Grier,[5] N. M., Range of Information Test in Biology. III Botany.
4. Ruch, G. M. and Cossman,[6] L. H., Content in High School Biology.
5. Cooprider,[7] J. L., Information Exercises in Biology.
6. King,[8] T. S. The Virginia Biology Test.

Grier's range of information tests in biology for physiology, zoology, and botany were developed in 1918. Each of these tests was composed of 100 test words. In physiology, a list was first prepared of all those words pertaining more directly to physiology discovered in spellers and readers previously used by the pupils in their grade-school work. A similar list was made from a number of the articles dealing with pure food and health to be found in daily newspapers and more widely known monthly magazines. From these lists, 100 of the more frequently occurring words were checked in the glossary of the textbook as being (1) words in fairly common use and (2) words, a knowledge of which, would indicate some familiarity with the care of the body.

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[2] Other studies herein referred to are properly listed in the bibliography.

[3] Grier, N. M., *Range of Information Test in Biology. I. Physiology.* The Journal of Educational Psychology, April, 1918. Vol. IX, pp. 210–216.

[4] ..... *Range of Information Test in Biology. II. Zoology.* The Journal of Educational Psychology, September, 1918, Vol. IX, pp. 388–392.

[5] ..... *Range of Information Test in Biology. III. Botany.* The Journal of Educational Psychology, December, 1919, vol. X, pp. 509–515.

[6] Ruch, G. M. and Cossman, L. H., *Content in High School Biology.* Journal of Educational Psychology, May, 1925, vol. XV, pp. 289–296.

[7] Cooprider, J. L., *Information Exercises in Biology.* School Science and Mathematics, November, 1925, vol. XXV, No. 8, pp. 807–813.

[8] King, T. S., *The Virginia Biology Test for High School Pupils.* Master's Thesis, University of Virginia, 1927.

The methods used in the development of the zoology and botany tests were the same as those used for the physiology test, except lists of words were prepared from Boy Scout and Camp Fire Girls publications instead of newspapers and monthly magazines.

The tests were not checked against outside criteria nor have they been standardized.

These tests were followed by a more general one by Professors G. M. Ruch and L. H. Cossman in 1924. The Ruch-Cossman Biology Test consists of items drawn from both botany and zoology and is published in two equivalent forms. The authors selected the items for their test from examination papers of 126 bioligy teachers in 23 states. Seventy-seven leading teachers and authorities rated the two thousand questions received and those passed as satisfactory and representative were used for the test. The coefficients of reliability obtained on Oregon and Iowa pupils range from .80 to .90.

Information Exercises in Biology were devised by J. L. Coop-rider in 1925. The test is an outgrowth of several years' experimentation in the selection of significant questions in biology. It is published in a single form and has a reliability of .92. This value was obtained from the results of 577 pupils taking the test. The items of the test are not scaled and are not arranged in the order of difficulty. No outside criteria were used in validating the test.

Mr. T. S. King constructed the Virginia Biology Test in 1928. This test was arranged from the material previously validated by Professors Ruch and Cossman. The test is not complete as Form B is under construction. Standards for Form A are not available.

While the principles, theories, and practices of test construction were taken into account in planning this investigation leading to the construction of biology tests (Chapter III), it should be reemphasized that the outstanding feature of this study is the fact that an effort has been made to establish the validity of these tests in a more comprehensive fashion than has been the practice in formulating any previous tests in biology (see Chapter I, pages 13).

The principles of test construction (discussed in Chapter III) for this study are based chiefly on Ruch and Stoddard's "Tests and Measurements in High School Instruction"[9] and Ruch's "The Improvement of the Written Examination."[10] The latter was especially helpful in suggesting the fundamental steps in the selection of test-items.

The statistical procedure used in this study is based largely on Rugg's[11] "Statistical Methods Applied to Education" and Garrett's[12] "Statistics in Psychology and Education."

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[9] Ruch, G. M. and Stoddard, George D., *Tests and Measurements in High School Instruction.* World Book Company, 1927.

[10] Ruch, G. M., *The Improvement of the Written Examination.* Scott, Foresman and Company, 1924.

[11] Rugg, Harold O., *Statistical Methods Applied to Education.* Houghton Mifflin Company, 1917.

[12] Garrett, Henry E., *Statistics in Psychology and Education.* Longmans, Green and Company, 1926.

II

Analysis of Material

In order for a test to possess validity or that it measure what it purports to measure, it is necessary that the content be composed of subject matter of recognized importance. The items composing the test must represent a general sampling of the essentials of subject matter which pupils are expected to master. Finally, the items must be determined upon the basis of more than subjective judgment or personal opinion. Criteria must be set up for the selection of the test-items, for construction of the experimental and final forms of the test, for derivation of standards, and for determination of reliability of the test.

The sources used in this study for the selection of the test material are (1) textbooks (2) teachers' final examination questions (3) College Entrance Examination Board questions (4) Board of Regents for the State of New York examination questions (5) courses of study from state departments of education and (6) courses of study from public secondary schools. An analysis of these data is presented in this chapter. Other criteria of validation and reliability employed and found in subsequent chapters of this study are (1) judgments of competent persons in evaluating the original list of test-items (2) correlations of test scores with school marks and (3) correlations of test scores with a previously validated measure.[1]

1. *Textbooks*

The textbooks analyzed in this study are those in most general use in the public secondary schools of the United States. Heads of state departments of education and principals of secondary schools in two large cities (see Appendix 1) of each state were asked to list the textbooks of biology in most general use in the schools of their respective states. Also, two hundred seventy-four biology teachers in city secondary schools (see Appendix 1)

[1] Ruch-Cossman Biology Test, Forms A and B.

were asked to give the name of the biology text used in their respective schools. The results of these inquiries are shown in Table 1.

TABLE I

REPLIES OF HEADS OF STATE DEPARTMENTS OF EDUCATION, SECONDARY SCHOOL PRINCIPALS, AND BIOLOGY TEACHERS ON THE USE OF BIOLOGY TEXTBOOKS

Source of Information	Number requested to submit titles of textbooks in general use	Number reporting titles of textbooks in general use	Number reporting no uniformity in use of textbooks	Number reporting "unable to answer"	Number not replying	Number reporting Biology not taught	Number States represented
Heads of departments of education.....	48	32	6	5	5		32
Secondary school principals*.....	98	61		21	16		40
Biology teachers..	274	152			111	11	46

* The principals of the secondary schools of Washington, D. C., and Juneau, Alaska, are included in this group.

One hundred and sixty-three responses were received from the two hundred seventy-four biology teachers who were requested to give the title of the biology textbooks used in their schools. Titles of textbooks were submitted by one hundred fifty-two teachers. Eleven teachers reported that biology was not taught in their schools. The number of states represented by the biology teachers is forty-six.

The distribution of the replies by states from heads of state departments of education, secondary school principals, and biology teachers is given in Appendix I.

Table II shows the extent to which the biology textbooks reported are used in public secondary schools. For instance, five heads of state departments of education report "Living Things", by Clement, as in most general use in the public secondary schools of their states and eight city public secondary school principals in seven states make a similar report. Twelve

biology teachers from schools in nine states state that they use the Clement text. Indications as to the extent to which the other thirteen texts are used are also shown in this table.

Of the textbooks listed in Table II, seven are shown to be used extensively in the public secondary schools. These texts were therefore selected for analysis, and are designated as

TABLE II

BIOLOGY TEXTBOOKS THAT ARE USED IN THE PUBLIC SECONDARY SCHOOLS OF THE UNITED STATES

Author and Title	Responses of state departments of education	Responses of city school principals	States represented by city school principals	Responses of biology teachers	States represented by biology teachers
Atwood Civic and Economic Biology	1	—	—	3	2
Clement Living Things	5	8	7	12	9
Gruenberg Biology and Human Life	7	10	9	15	13
Gruenberg Elementary Biology	7	6	5	13	10
Hunter Civic Biology	2	2	1	3	2
Hunter New Essentials of Biology	16	21	19	18	14
Linville Biology of Man and Other Living Things	—	2	2	1	1
Moon Biology for Beginners	6	15	13	32	21
Peabody and Hunt Biology and Human Welfare	10	12	10	16	11
Peabody and Hunt Elementary Biology	1	—	—	2	2
Smallwood, Reveley and Bailey New Biology	15	18	12	44	29
Smallwood, Reveley and Bailey Biology for High Schools	2	1	1	3	1
Trafton Biology of Home and Community	1	—	—	2	1
Williams Healthful Living	1	—	—	1	1

A, B, C, D, E, F, and G. This analysis of texts is made in Table III in order to determine the general plan of organization of biological material, content of subject matter, and the arrangement of the topics. It shows the number of pages devoted to each of these topics. Table III indicates, for example, that 13.2 pages are devoted to cells in textbook "A" and 4.9 pages are given in textbook "B". The total number of pages devoted to cells in the seven textbooks is 57.6, which is 1.55 per cent of the total number of pages in these textbooks. The total number of pages of instruction contained in the seven textbooks is 3,719.5.

A preliminary sampling of twenty pages was made of each textbook analyzed covering the size of pages, the number of lines on a page, and the number of words in a line to establish a method of procedure for the comparative analysis that is recorded in Table III. Tables of contents, prefaces, general review questions, suggestions to teachers and pupils, references, appendices, and indices are not included in the analysis. All pages containing illustrative material such as diagrams, tables and half-tones were given the same weight as the subject matter in contextual form. The pages of each textbook were carefully examined one by one. Entries were made on cards showing the name of the textbook and the title of each topic with the amount of page space devoted to each, respectively. Fractional parts of pages were determined by counting the number of lines on the particular pages that contained more than one topic and by calculating the portion of the entire page of which such topics were a part. For example, on a page of thirty-five lines, fruits occupy twenty-eight lines and seed dispersal seven. The space devoted to fruits is eight-tenths of a page and to seed dispersal two-tenths. The majority of the fractional pages listed in Table III, however, are accounted for and are due to the fractional pages at the end of chapters. The cards were separated and the topics arranged under the main divisions of biology, namely, plant biology, animal biology, and human biology. Those topics, which are very general in nature and apply equally to each of the three main divisions of the subject, are grouped under miscellaneous topics.

TABLE III

NUMBER AND PER CENT OF PAGES IN THE SEVEN SELECTED TEXTBOOKS DEVOTED TO THE VARIOUS TOPICS OF BIOLOGY

Section A: Plant Biology

TOPICS	TEXTBOOKS							TOTAL NUMBER OF PAGES	AVERAGE NUMBER OF PAGES	PER CENT OF TOTAL SPACE
	A	B	C	D	E	F	G			
Cells	13.2	4.9	5.7	14.2	6.8	7.6	5.2	57.6	8.23	1.55
Seeds	13.0	8.2	24.5	11.8	9.1	10.4	20.7	97.7	13.96	2.62
Roots	11.3	7.6	9.3	5.4	8.9	5.2	7.4	55.1	7.87	1.48
Stems	12.8	5.3	18.1	4.5	12.2	2.9	12.4	68.2	9.74	1.85
Forestry	27.4	9.2	12.7	8.6	13.2	12.4	9.7	93.2	13.31	2.50
Leaves	13.2	10.8	21.6	14.1	13.8	5.1	13.9	92.5	13.21	2.49
Plant physiology	17.2	51.4	16.8	3.2	18.4	23.2	7.1	137.3	19.61	3.69
Flowers	23.5	10.2	16.7	18.8	7.1	15.6	17.2	109.1	15.59	2.93
Fruits	11.6	9.7	2.1	....	9.8	....	10.2	43.4	6.20	1.17
Plant breeding	6.8	....	1.2	15.5	....	16.2	2.4	42.1	6.01	1.13
Bacteria	12.1	11.9	13.4	9.8	12.9	2.4	9.6	72.1	10.30	1.94
Lower forms of plants	8.8	5.8	8.2	4.5	10.4	3.7	13.1	54.5	7.79	1.46
Soil	15.6	6.1	5.5	3.4	2.1	7.9	3.2	43.8	6.26	1.18
Economics of plants	1.2	....	18.9	21.4	7.1	9.3	8.9	66.8	9.54	1.80
Classification of plants	....	5.2	....	....	....	21.8	3.3	30.3	4.33	.81
Conservation of plants	2.6	1.3	....	12.8	....	17.1	2.5	36.3	5.19	.98
Symbiosis	24.2	....	....	....	7.4	....	7.8	39.4	5.63	1.06
Total	214.5	147.6	174.7	148.0	139.2	160.8	154.6	1139.4	162.77	30.64

TABLE III—*Continued*

Section B: Animal Biology

TOPICS	TEXTBOOKS							TOTAL NUMBER OF PAGES	AVERAGE NUMBER OF PAGES	PER CENT OF TOTAL SPACE
	A	B	C	D	E	F	G			
Insects	56.8	51.2	46.9	53.2	19.7	8.4	25.8	262.0	37.43	7.04
Crustaceans	12.7	1.2	12.6	7.9	6.2	1.9	12.4	54.9	7.84	1.48
Worms	5.2	....	11.4	....	....	2.1	9.7	28.4	4.06	.76
Molluscs	3.9	2.2	....	....	....	1.3	6.7	14.1	2.01	.38
Protozoa	4.2	....	7.9	7.5	8.6	10.7	9.4	48.3	6.90	1.30
Simple metazoa	5.7	....	7.1	....	1.3	1.8	9.4	25.3	3.61	.68
Amphibians	19.4	2.1	20.8	16.4	10.7	6.6	8.2	84.2	12.03	2.27
Fishes	17.3	1.9	13.1	20.6	10.2	3.4	13.3	79.8	11.40	2.15
Reptiles	9.1	....	7.8	....	....	1.2	5.1	23.2	3.32	.62
Birds	32.7	5.1	29.4	32.6	24.5	5.9	7.4	137.6	19.66	3.70
Mammals	37.2	....	10.7	15.5	16.4	4.1	7.6	91.5	13.07	2.46
Classification of animals	3.8	9.6	4.2	....	....	13.1	2.4	33.1	4.73	.89
Animal Breeding	....	4.7	2.1	....	6.2	12.9	....	25.9	3.70	.70
Life Processes	8.7	57.2	4.1	18.7	4.8	14.6	5.1	113.2	16.17	3.04
Economics of invertebrates	2.9	....	12.1	....	5.8	29.7	4.2	54.7	7.81	1.46
Economics of vertebrates	3.7	....	10.2	....	4.8	5.2	5.4	29.3	4.19	.79
Total	223.3	135.2	200.4	172.4	119.2	122.9	132.1	1105.5	157.93	29.72

TABLE III—*Continued*

Section C: Human Biology

TOPICS	TEXTBOOKS							TOTAL NUMBER OF PAGES	AVERAGE NUMBER OF PAGES	PER CENT OF TOTAL SPACE
	A	B	C	D	E	F	G			
Structure	29.4	....	....	15.5	12.8	10.6	13.6	81.9	11.70	2.20
Foods	21.5	48.8	20.7	48.3	19.4	44.6	15.2	218.5	31.21	5.87
Digestion	16.4	7.5	19.1	20.4	19.8	7.6	15.3	106.1	15.15	2.85
Respiration	11.6	12.3	10.4	16.5	13.8	17.3	8.7	90.6	12.95	2.44
Circulation	18.4	21.9	10.7	24.2	5.7	16.9	15.6	113.4	16.20	3.05
Nervous system	21.1	38.2	16.8	15.2	12.6	41.6	15.1	160.6	22.95	4.32
Excretion	5.9	11.8	5.3	3.4	2.8	6.2	6.4	41.8	5.97	1.12
Health	46.2	37.1	22.5	31.4	37.8	141.3	22.1	338.4	48.34	9.10
Stimulants, narcotics and drugs	11.8	2.3	15.7	12.8	22.4	....	5.7	70.7	10.10	1.90
Total	182.3	179.9	121.2	187.7	147.1	286.1	117.7	1222.0	174.57	32.85

Section D: Miscellaneous Topics

TOPICS	TEXTBOOKS							TOTAL NUMBER OF PAGES	AVERAGE NUMBER OF PAGES	PER CENT OF TOTAL SPACE
	A	B	C	D	E	F	G			
Introductory material	23.2	7.9	24.3	28.8	20.5	13.4	18.7	136.8	19.54	3.68
Heredity and evolution	18.2	39.5	20.8	12.9	....	3.4	....	94.8	13.54	2.55
Biography	....	....	14.5	....	6.5	....	....	21.0	3.00	.56
Total	41.4	47.4	59.6	41.7	27.0	16.8	18.7	252.6	36.08	6.79

TABLE III—*Continued*

Summary

TOPICS	TEXTBOOKS							TOTAL NUMBER OF PAGES	AVERAGE NUMBER OF PAGES	PER CENT OF TOTAL SPACE
	A	B	C	D	E	F	G			
Total plant biology	214.5	147.6	174.7	148.0	139.2	160.8	154.6	1139.4	162.77	30.64
Total animal biology	223.3	135.2	200.4	172.4	119.2	122.9	132.1	1105.5	157.93	29.72
Total human biology	182.3	179.9	121.2	167.7	147.1	286.1	117.7	1222.0	174.57	32.85
Total miscellaneous biology	41.4	47.4	59.6	41.7	27.0	16.8	18.7	252.6	36.08	6.79
Grand Total	661.5	510.1	555.9	549.8	432.5	586.6	423.1	3719.5	531.35	100.00

The writer finds that the topics listed in Table III are those commonly included in biology textbooks and they form the bases of the recommendations of state and city courses of study. On the strength of the above distribution, the number of topics used in this study is forty-five, of which there are 17 for plant biology, 16 for animal biology, 9 for human biology, and 3 for miscellaneous topics. These topics are not found in all of the texts, but they are used by the majority of the writers. A few concrete examples illustrate this situation: fruits are not treated in Texts D and F; protozoa are not discussed in Text B; and stimulants, narcotics, and drugs are omitted in Text F. Topics which, in the judgment of the writer, are closely related were grouped in order to reduce the number of units to be handled. For example, plant physiology includes such work of plants as respiration, transpiration, and photosynthesis.

TABLE IV

DISTRIBUTION OF TOPICS IN THE SEVEN TEXTBOOKS

Section A: Plant Biology

NO.	TOPIC	AVERAGE NUMBER OF PAGES	PER CENT OF TOTAL SPACE DEVOTED TO EACH TOPIC	RANK ORDER
1	Plant physiology	19.61	3.69	1
2	Flowers	15.59	2.93	2
3	Seeds	13.96	2.62	3
4	Forestry	13.31	2.50	4
5	Leaves	13.21	2.49	5
6	Bacteria	10.30	1.94	6
7	Stems	9.74	1.85	7
8	Economics of plants	9.54	1.82	8
9	Cells	8.23	1.55	9
10	Roots	7.87	1.48	10
11	Lower forms of plants	7.79	1.46	11
12	Soil	6.26	1.18	12
13	Fruits	6.20	1.17	13
14	Plant breeding	6.01	1.13	14
15	Symbiosis	5.63	1.06	15
16	Conservation of plants	5.19	.98	16
17	Classification	4.33	.81	17

TABLE IV—*Continued*

Section B: Animal Biology

NO.	TOPIC	AVERAGE NUMBER OF PAGES	PER CENT OF TOTAL SPACE DEVOTED TO EACH TOPIC	RANK ORDER
1	Insects	37.43	7.04	1
2	Birds	19.66	3.70	2
3	Life processes	16.17	3.04	3
4	Mammals	13.07	2.46	4
5	Amphibians	12.03	2.27	5
6	Fishes	11.40	2.15	6
7	Crustaceans	7.84	1.48	7
8	Economics of invertebrates	7.81	1.46	8
9	Protozoa	6.90	1.30	9
10	Classification of animals	4.73	.89	10
11	Economics of vertebrates	4.19	.79	11
12	Worms	4.06	.76	12
13	Animal breeding	3.70	.70	13
14	Simple metazoa	3.61	.68	14
15	Reptiles	3.32	.62	15
16	Molluscs	2.01	.38	16

Section C: Human Biology

NO.	TOPIC	AVERAGE NUMBER OF PAGES	PER CENT OF TOTAL SPACE DEVOTED TO EACH TOPIC	RANK ORDER
1	Health	48.34	9.10	1
2	Foods	31.21	5.87	2
3	Nervous system	22.95	4.32	3
4	Circulation	16.20	3.05	4
5	Digestion	15.15	2.85	5
6	Respiration	12.95	2.44	6
7	Structure	11.70	2.20	7
8	Stimulants, narcotics and drugs	10.10	1.90	8
9	Excretion	5.97	1.12	9

Section D: Miscellaneous Topics

NO.	TOPIC	AVERAGE NUMBER OF PAGES	PER CENT OF TOTAL SPACE DEVOTED TO EACH TOPIC	RANK ORDER
1	Introductory material	19.54	3.68	1
2	Heredity and evolution	13.54	2.55	2
3	Biography	3.00	.56	3

Table IV shows the average number of pages and the per cent of space in the seven textbooks devoted to each topic of biology in each of the four sections. The rank order of these topics is also shown.

The tabulation shows very clearly that many of the topics of biology receive a great deal of attention, whereas others are scarcely treated at all. That there is a substantial agreement existing in the various texts relative to the number of pages devoted to each topic has been shown in Table III.

In Table V, all the topics included in Sections A, B, C, and D of Table IV are put together and ranked according to the average number of pages devoted to each of the forty-five topics. Those topics receiving the greatest amount of emphasis are health, insects, and foods, respectively. On the other hand there are ten topics to which less than an average number of five pages are devoted in the seven textbooks.

Five of the textbooks that were analyzed were found to be arranged according to the separate biological sciences, namely, plant biology and animal and human biology. The other two have the material arranged in the order of a general course so that plant and animal life are taken together as a unit. Of the seven texts, those reported as in most general use have the subject matter arranged in the separate biological sciences.

The writer has given emphasis to the analysis of biology textbooks because they are important factors in the teaching of biology in the secondary schools. An analysis of textbooks presents the judgments of competent persons because, the content of each text represents the judgment of one or more supposedly competent persons in the field. Teachers are inclined to accept the textbook organization of material as a basis for their courses. In fact, in many cases teachers probably would be at a loss to attempt to conduct their classes without texts. Biology textbooks are widely used and consequently the selection of a large number of items for a test on the basis of occurrence in from 75 to 100 per cent of the leading textbooks of biology indicates the general teaching practice throughout the country in the subject.

TABLE V

RANK ORDER OF ALL TOPICS IN BIOLOGY IN THE SEVEN TEXTBOOKS

NO.	TOPIC	RANK ORDER	NO.	TOPIC	RANK ORDER
1	Health (man)	1	23	Stems	23
2	Insects	2	24	Economics of plants	24
3	Foods	3	25	Cells	25
4	Nervous system (man)	4	26	Roots	26
5	Birds	5	27	Crustaceans	27
6	Plant Physiology	6	28	Economics of invertebrates	28
7	Introductory material	7	29	Lower forms of plants	29
8	Circulation (man)	8	30	Protozoa	30
9	Life processes (animals)	9	31	Soil	31
10	Flowers	10	32	Fruits	32
11	Digestion (man)	11	33	Plant breeding	33
12	Seeds	12	34	Excretion (man)	34
13	Heredity and evolution	13	35	Symbiosis	35
14	Forestry	14	36	Conservation of plants	36
15	Leaves	15	37	Classification (animals)	37
16	Mammals	16	38	Classification (plants)	38
17	Respiration (man)	17	39	Economics of vertebrates	39
18	Amphibians	18	40	Worms	40
19	Structure (man)	19	41	Animal breeding	41
20	Fishes	20	42	Simple metazoa	44
21	Bacteria	21	43	Reptiles	43
22	Stimulants, narcotics, and drugs (man)	22	44	Biography	44
			45	Molluscs	25

2. *Teachers' Examination Questions in Biology*

In order to ascertain the content of biology work throughout the country as revealed by examination questions, the writer communicated with teachers in cities of three classes based upon population. Letters were sent to biology teachers in six cities of each state with the exception of Arizona, Delaware, Nevada, New Mexico, and Utah. From the latter only sixteen teachers were selected because there were not enough cities of each class from which to secure information. In all, 274 biology teachers were asked to send sets of examination questions. Appendix II shows in detail the distribution of the responses. Table VI is a summary of this appendix.

TABLE VI

DISTRIBUTION OF SETS OF EXAMINATION QUESTIONS RECEIVED FROM BIOLOGY TEACHERS THROUGHOUT THE UNITED STATES

STATES	CITIES OF 100,000 POPULATION AND OVER	CITIES OF 25,000 TO 100,000 POPULATION	CITIES AND RURAL COMMUNITIES UNDER 25,000 POPULATION
45	31	46	65

It is indicated in Table VI that 142 sets of examination questions were received from teachers in 142 cities located in 45 states. The total number of questions received and analyzed was 9052; 3202 questions were received from cities of 100,000 population and over, 3926 questions from cities of a population from 25,000 to 100,000, and 1924 questions from cities of less than 25,000 population including rural communities. This distribution is representative of the three classes of population, of the several states, and of the country at large.

Most of the sets of questions were marked either as Biology I and Biology II or as First Semester Biology and Second Semester Biology. A few of the sets were marked Plant Biology and Animal and Human Biology. Table VII shows the distribution of the examination questions according to the topics of biology covered. This table also indicates the total number of questions asked, the per cent of the questions devoted to each of the topics, and the rank order of the topics. The rank order is found by arranging the per cent column from highest to lowest.

It will be noted that the topics to which the largest per cent of questions are devoted in plant biology are plant physiology, seeds, and flowers; in animal biology insects, birds, and crustaceans; in human biology health, foods, and circulation; and in the miscellaneous topics introductory materials. Those topics receiving the least per cent of questions in plant biology are symbiosis, conservation of plants, and plant breeding; in animal biology molluscs, reptiles, and animal breeding; in human biology excretion, respiration, and stimulants, narcotics, and drugs; and in the miscellaneous topics biography. It is also

significant that among the first ten topics ranked according to the per cent of questions asked, four are taken from plant biology, four from human biology, one from animal biology, and one from miscellaneous biology material. Similarly, among the last ten topics ranked according to the per cent of questions asked, five are taken from plant biology, four from animal biology, and one from human biology. However, a more accurate picture of the emphasis placed upon the different divisions of biology is disclosed by a study of the rank order of the main body of the topics, excluding the upper and lower ten. In this group 47 per cent of the plant biology topics are included, 50 per cent of the animal biology, 55 per cent of the human biology, and 66 per cent of the miscellaneous biology material.

The data of Table VII are of interest with reference to the content of the biology questions and the distribution of this content in the main divisions of the subject: 9502 questions were analyzed; 3486 or 38.44 per cent were devoted to plant biology, 2902 or 32.01 per cent to animal biology, 1944 or 21.49 per cent to human biology, and 720 or 8.06 per cent to miscellaneous biology material.

TABLE VII
DISTRIBUTION OF EXAMINATION QUESTIONS OF BIOLOGY TEACHERS
Section A: Plant Biology

TOPICS	NUMBER OF QUESTIONS	PER CENT OF QUESTIONS	RANK
Cells	230	2.54	15
Seeds	418	4.61	3
Roots	258	2.85	11.5
Stems	354	3.91	5
Forestry	84	.93	36
Leaves	229	2.53	16
Plant physiology	420	4.63	2
Flowers	401	4.43	4
Fruits	224	2.42	18
Plant breeding	26	.29	44
Bacteria	201	2.22	24
Lower forms	172	1.90	29
Soil	103	1.14	35
Economics of plants	179	1.98	27
Classification of plants	81	.89	38
Conservation of plants	46	.51	43
Symbiosis	60	.66	42
Total	3486	38.44	

TABLE VII—*Continued*

Section B: Animal Biology

TOPICS	NUMBER OF QUESTIONS	PER CENT OF QUESTIONS	RANK
Insects	517	5.71	1
Crustaceans	223	2.41	19
Worms	140	1.54	31
Molluscs	78	.88	39
Protozoa	205	2.26	22
Simple metazoa	82	.91	37
Amphibians	192	2.12	25
Fishes	252	2.79	14
Reptiles	72	.80	41
Birds	268	2.95	10
Mammals	148	1.64	30
Classification of animals	178	1.97	28
Animal breeding	24	.26	45
Life processes	224	2.47	17
Economics of invertebrates	182	2.01	26
Economics of vertebrates	117	1.29	33
Total	2902	32.01	

Section C: Human Biology

TOPICS	NUMBER OF QUESTIONS	PER CENT OF QUESTIONS	RANK
Structure	256	2.84	13
Foods	310	3.42	7
Digestion	208	2.30	21
Respiration	114	1.26	34
Circulation	280	3.10	8
Nervous system	209	2.31	20
Excretion	79	.87	40
Health	350	3.87	6
Stimulants, narcotics and drugs	138	1.52	32
Total	1944	21.49	

Section D: Miscellaneous Topics

TOPICS	NUMBER OF QUESTIONS	PER CENT OF QUESTIONS	RANK
Introductory material	260	2.98	9
Heredity and evolution	258	2.85	11.5
Biography	202	2.23	23
Total	720	8.06	

TABLE VII—*Continued*

Summary

TOPICS	NUMBER OF QUESTIONS	PER CENT OF QUESTIONS
Total plant biology	3486	38.44
Total animal biology	2902	32.01
Total human biology	1944	21.49
Total miscellaneous	720	8.06
Grand total	9052	100.00

The data of Table III, analysis of textbooks, are in close agreement with the data of Table VII. The coefficient of correlation between these two tables is .794. This high correlation suggests a close relationship between the emphasis on the topics in the textbooks and the importance of topics in the minds of the teachers preparing the examination questions. It is quite probable that the teachers are largely guided by the textbook emphasis.

The analysis of textbooks in Section 1 presents evidence of the organization of subject matter for secondary school biology, but the data obtained from an analysis of final examination questions present evidence that is more definite and is indicative of the material taught as revealed through final examinations. Many unimportant details are contained in textbooks, mastery of which it is practically impossible for pupils to attain or even attempt in the time allotted for the work. Final examination questions represent an attempt on the part of the teachers preparing them to exercise care and thought in selecting the most important material of the course and the elimination of non-essentials and unimportant details. The selection of items for a test based upon an analysis of teachers' final examination questions suggests an additional check over the textbook method. It is apparent to the writer, therefore, that the content of final examination questions reveals definitely the subject matter of biology as that work is actually being tested in the schools. An analysis of teachers' questions was, consequently, considered one of the important criteria to justify the data used in formulating the items of the tests.

3. *Examination Questions of the College Entrance Examination Board and the Board of Regents for the State of New York*

The examination questions of the College Entrance Examination Board and of the Board of Regents for the State of New York were analyzed for the period of 1916 to 1926. The object of this analysis was to determine which topics of biology the examining boards included most frequently. This was disclosed by a study of the questions asked; 371 questions of the College Entrance Examination Board were analyzed, while the total number of the Board of Regents was 876. These questions cover a period of ten years. Where a question had subheads, each part was counted separately. The questions of the Board of Regents are given specific value on the examination papers, while those of the College Entrance Examination Board are not. Since there is no basis for comparison, the values assigned to the Regents' questions are disregarded in this study. The questions of both boards have been published from time to time and are available for general use.

The distribution of the topics of biology as represented by the number and per cent of questions asked is shown in Table VIII. The writer arranged the questions under the classification of topics used in previous sections of this chapter where textbooks and teachers' final examination questions were analyzed. Of course, the questions were not presented in examinations under such groupings, but it is necessary to make a grouping for the purposes of comparison. Table VIII also indicates the rank order of the topics referred to in terms of the questions asked by each board. There are only a few topics that are emphasized to a greater extent by one board than the other. Naturally, two separate and distinct examining boards will vary somewhat in the emphasis placed upon the different topics. However, the summary of table VIII shows that the total number and per cent of questions devoted to the main divisions of biology (plant, animal, human, and miscellaneous topics) by the examining boards is about the same. The summary of Table VIII indicates that 42.05 per cent of the questions asked by the College

Entrance Examination Board refer to plant biology and that 39.92 per cent of the questions asked by the Board of Regents refer to the same division of biology. Similarly, 30.18 per cent of the questions asked by the former board refer to animal biology and 26.47 per cent asked by the latter refer to the same division. This summary also shows that plant biology receives a great deal more emphasis than the other divisions of the subject. Approximately 12.00 per cent more questions are given to plant biology than are devoted to the next highest division of the subject by each board. This is probably accounted for by the fact that botany was the first of the biological sciences to be taught in the secondary schools and that its influence is still felt to a greater extent than that of either zoology or physiology.[2]

TABLE VIII

DISTRIBUTION OF TOPICS IN BIOLOGY ACCORDING TO EXAMINATION QUESTIONS OF THE COLLEGE ENTRANCE EXAMINATION BOARD AND OF THE BOARD OF REGENTS FOR THE STATE OF NEW YORK FROM 1916 TO 1926

Section A: Plant Biology

TOPICS	COLLEGE ENTRANCE EXAMINATION BOARD			BOARD OF REGENTS		
	NO. OF QUESTIONS	PER CENT OF QUESTIONS	RANK	NO. OF QUESTIONS	PER CENT OF QUESTIONS	RANK
Cells	15	4.04	7.5	26	2.96	14
Seeds	17	4.58	5	51	5.82	3
Roots	15	4.04	7.5	21	2.40	18
Stems	7	1.89	21	32	3.65	9
Forestry	2	.54	39.5	17	1.94	21.5
Leaves	6	1.62	24	28	3.19	12.5
Plant physiology	27	7.29	1	56	6.39	2
Flowers	4	1.08	30	28	3.19	12.5
Fruits	9	2.43	18	10	1.14	29.5
Plant Breeding	..	....	....	1	.11	38
Bacteria	10	2.69	14	23	2.62	16.5
Lower forms	14	3.77	8.5	7	.80	32.5
Soil	4	1.08	30	11	1.26	27.5
Economics of plants	9	2.43	18	15	1.71	25
Classification of plants	7	1.89	21	..	....	....
Conservation of plants	2	.54	39.5	8	.91	31
Symbiosis	8	2.16	18	16	1.83	23.5
Total	156	42.05		350	39.92	

[2] Nelson, George E., *History of the Biological Sciences in Secondary Schools of the United States.* School Science and Mathematics, vol. XXVIII, January, 1928, p. 36.

TABLE VIII—*Continued*

Section B: Animal Biology

TOPICS	COLLEGE ENTRANCE EXAMINATION BOARD			BOARD OF REGENTS		
	NO. OF QUESTIONS	PER CENT OF QUESTIONS	RANK	NO. OF QUESTIONS	PER CENT OF QUESTIONS	RANK
Insects	10	2.69	14	33	3.76	8
Crustaceans	6	1.62	24	23	2.62	16.5
Worms	..	....	....	1	.11	38
Molluscs	3	.81	33	..	....	....
Protozoa	10	2.69	14	17	1.94	21.5
Simple metazoa	2	.54	39.5	..	....	....
Amphibians	12	3.23	10.5	25	2.85	15
Fishes	14	3.77	8.5	12	1.37	26
Reptiles	..	....	....	..	....	....
Birds	3	.81	33	31	3.54	10.5
Mammals	6	1.62	24	5	.57	34
Classification of animals	7	1.89	21	..	....	....
Animal breeding	..	....	....	1	.11	38
Life processes	22	5.93	2	48	5.49	4
Economics of invertebrates	12	3.23	10.5	20	2.28	19
Economics of vertebrates	5	1.35	27	16	1.83	23.5
Total	112	30.18		232	26.47	

Section C: Human Biology

TOPICS	COLLEGE ENTRANCE EXAMINATION BOARD			BOARD OF REGENTS		
	NO. OF QUESTIONS	PER CENT OF QUESTIONS	RANK	NO. OF QUESTIONS	PER CENT OF QUESTIONS	RANK
Structure	10	2.69	14	19	2.17	20
Foods	17	4.58	5	42	4.84	5
Digestion	4	1.08	30	31	3.54	10.5
Respiration	5	1.35	27	11	1.26	27.5
Circulation	3	.81	33	38	4.34	6
Nervous system	10	2.69	14	2	.23	35.5
Excretion	2	.54	39.5	10	1.14	29.5
Health	21	5.67	3	98	11.19	1
Stimulants, narcotics and drugs	..	....	....	7	.80	32.5
Total	72	19.41		258	29.51	

TABLE VIII—*Continued*

Section D: Miscellaneous Topics

TOPICS	COLLEGE ENTRANCE EXAMINATION BOARD			BOARD OF REGENTS		
	NO. OF QUESTIONS	PER CENT OF QUESTIONS	RANK	NO. OF QUESTIONS	PER CENT OF QUESTIONS	RANK
Introductory material..	17	4.58	5	34	3.87	7
Heredity and evolution.	9	2.43	18	..	....	....
Biography.....	5	1.35	27	2	.23	35.5
Total.....	31	8.36		36	4.10	

Summary

TOPICS	COLLEGE ENTRANCE EXAMINATION BOARD		BOARD OF REGENTS	
	NO. OF QUESTIONS	PER CENT OF QUESTIONS	NO. OF QUESTIONS	PER CENT OF QUESTIONS
Total plant biology....	156	42.05	350	39.92
Total animal biology...	112	30.18	232	26.47
Total human biology...	72	19.41	258	29.51
Total miscellaneous biology.....	31	8.36	36	4.10
Grand total.....	371	100.00	876	100.00

The individual topics of biology which received the largest as well as the least amount of consideration can be ascertained by a study of Table VIII. Attention may be called to the fact that in plant biology among the leading topics were seeds and plant physiology. The boards differed in stressing such topics as flowers and stems, one giving 1.08 per cent of the questions to flowers and the other 3.19 per cent, and 1.89 per cent to stems and the other 3.65 per cent. Among the topics receiving the least consideration are conservation of plants and plant breeding. In animal biology, the topics which receive the greatest amount of emphasis are life processes and amphibians. Such topics as birds and crustaceans differed in the stress that they received by the boards, one giving .81 per cent of the questions to birds and the other 3.54 per cent, and 1.62 per cent to

crustaceans and the other 2.62 per cent. Simple metazoa and animal breeding are among the topics receiving the least consideration. Health and foods are the outstanding topics of human biology. Digestion and circulation each vary in the amount of emphasis that the separate boards devote to them in that one board gives 1.08 per cent of the questions to digestion and the other 3.54 per cent, and .81 per cent to circulation and the other 4.34 per cent. Very little emphasis is devoted to excretion and stimulants, narcotics, and drugs. It will be noted that most of the topics listed in Table VIII, which are stressed as well as those which received little consideration, were similarly emphasized in the analyses of textbooks (Table III) and teachers' final examination questions (Table VII).

The data presented in Table VIII indicate the topics of biology which are emphasized to the greatest extent and are included most frequently in the examinations of the College Entrance Examination Board and of the Board of Regents for the State of New York. The selection of these questions by the examining boards represents the pooled judgments of presumably competent individuals in the preparation of the examinations. An analysis of these questions has served the writer as an additional guide in the selection of items for the tests because they show the subject matter of biology which is considered by the examiners to be most worthwhile and the extent to which the various topics are treated.

4. *Courses of Study*

A. Courses Provided by State Departments of Education

Courses of study were examined in order to determine what consideration the content of biology is receiving from state departments of education. The heads of these departments were asked to submit copies of the courses of study for biology used in their respective states. Forty-six responses were received. The number of courses of study obtained was thirty-two. Fourteen of these contained topical outlines for biology work. The others consisted merely of aims, methods, and general suggestions. In eleven states, reports showed that there was no uni-

TABLE IX

COURSES OF STUDY IN BIOLOGY FOR SECONDARY SCHOOLS PROVIDED BY STATE DEPARTMENTS OF EDUCATION

STATES*	COURSE OUTLINED IN TWO UNITS**	COURSE OUTLINED IN A SINGLE UNIT	COURSE OUTLINED ONLY AS TO AIMS, METHODS AND EQUIPMENT	COURSE REPORTED "NOT UNIFORM"
Alabama			1	
Arkansas	1			
California				1
Colorado		1		
Connecticut				1
Delaware			1	
Florida			1	
Georgia			1	
Idaho	1			
Illinois				1
Indiana		1		
Iowa				1
Kansas	1			
Kentucky			1	
Louisiana			1	
Maine			1	
Maryland	1			
Massachusetts				1
Michigan			1	
Minnesota			1	
Mississippi			1	
Missouri	1			
New Hampshire				1
New Jersey	1			
New Mexico				1
New York	1			
North Carolina			1	
North Dakota				1
Ohio				1
Oklahoma	1			
Oregon			1	
Rhode Island				1
South Carolina			1	
South Dakota			1	
Tennessee			1	
Texas	1			
Utah			1	
Vermont				1
Virginia		1		
Washington	1			
West Virginia			1	
Wisconsin			1	
Wyoming	1			
Total	11	3	18	11

* States not indicated in table:
Arizona—"Course not prepared by state."
Nevada—"Course out of print."
Pennsylvania—"Course being prepared."
Montana and Nebraska—no reply.

** The units are (1) plant biology and (2) animal and human biology.

form course of study. The reasons for the failure of the other states to submit data is indicated in the footnote to Table IX. This table deals with the courses of study provided by states throughout the country.

In the majority of state courses of study, there is found a list of textbooks, suggestions relative to laboratory work and equipment and recommendations in regard to reference material for teachers and pupils. Eleven of the fourteen definitely outlined courses had the work arranged as plant biology and animal and human biology. The others had the work arranged as a single unit. The eighteen courses of study which did not contain topical outlines for biology work, confine themselves largely to a recapitulation of the principles of science teaching as laid down by the Commission on the Reorganization of Science in Secondary Schools, in Bulletin No. 26, *Reorganization of Science in Secondary Schools*, of the United States Bureau of Education.[3] The fundamental ideas set forth in this bulletin have reference to the place of the biological sciences in the curriculum, the changes in point of view in biology teaching, aims, sequence and continuity, and methods of biology work. Furthermore, no mention of content of subject matter is made in these eighteen courses of study other than to quote the very general recommendations of Bulletin No. 26. This bulletin gives as the central idea of a biology course:

"The way in which each organism maintains its own life and the life of the species.

"The interrelations between different organisms and groups of organisms.

"The constant dependence and interrelations of living things with the physical world about us

"The power of man to control the habits and relationships of plants and animals to serve his own ends."

Courses of study which use these statements as guiding principles in the selection of subject matter for the schools of their states, and which offer no further suggestions regarding

[3] *Reorganization of Science in Secondary Schools*, United States Bureau of Education Bulletin No. 26, 1920.

subject matter, give no indication of the work that is actually done. However, these courses of study have a value, in that they form a basis upon which local communities build their specific courses.

The distribution of subject matter as represented by the fourteen state courses of study that contained topical outlines for biology work is shown in Table X. The material recommended in these courses of study as shown in this table is similar to the content of textbooks (Table III) and to the subject matter considered in teachers' final examination questions (Table VII). Among the topics that received the least emphasis in state courses of study were: classification of plants, soil,

TABLE X

DISTRIBUTION OF SUBJECT MATTER IN FOURTEEN STATE COURSES OF STUDY

Section A: Plant Biology

TOPICS	COURSES OF STUDY														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Arkansas	Colorado	Idaho	Indiana	Kansas	Maryland	Missouri	New Jersey	New York	Oklahoma	Texas	Virginia	Washington	Wyoming	Total
Cells	..	√	√	√	√	√	√	√	√	√	√	√	√	√	13
Seeds	√	√	√	√	√	√	√	√	√	√	√	√	√	√	14
Roots	√	√	√	√	√	√	√	√	√	√	√	√	√	√	14
Stems	√	√	√	√	√	√	√	√	√	√	√	√	√	√	14
Forestry	√	√	..	√	√	√	..	..	√	√	√	..	√	√	10
Leaves	√	√	√	√	√	√	√	√	√	√	√	√	√	√	14
Plant physiology	√	√	√	√	√	√	√	√	√	√	√	√	√	√	14
Flowers	√	√	√	√	√	√	√	√	√	√	√	√	√	√	14
Fruits	√	√	√	√	√	√	√	√	√	√	√	√	√	√	14
Plant breeding	√	√	√	√	..	√	√	√	..	..	√	√	√	√	11
Bacteria	√	√	√	√	√	√	√	√	√	√	√	√	√	√	14
Lower forms	√	√	√	..	√	√	√	√	..	√	√	√	√	√	12
Soil	√	√	√	..	√	√	..	√	..	..	..	√	√	..	8
Economics of plants	√	√	√	√	√	√	√	√	√	√	√	√	√	√	14
Classification of plants	..	..	..	√	√	√	..	√	..	√	..	..	√	√	7
Conservation of plants	√	√	..	√	√	√	..	√	√	..	√	√	..	√	10
Symbiosis	..	√	..	√	√	√	..	√	√	..	√	..	..	√	8
Total number of topics	14	16	13	15	16	17	12	16	13	13	15	14	15	16	205

√ Indicates topics recommended to be taught.

TABLE X—*Continued*

Section B: Animal Biology

TOPICS	COURSES OF STUDY														
	1 Arkansas	2 Colorado	3 Idaho	4 Indiana	5 Kansas	6 Maryland	7 Missouri	8 New Jersey	9 New York	10 Oklahoma	11 Texas	12 Virginia	13 Washington	14 Wyoming	15 Total
Insects	√	√	√	√	√	√	√	√	√	√	√	√	√	√	14
Crustaceans	√	√	√	√	√	√	√	. .	√	√	√	√	√	√	13
Worms	√	√	√	√	√	√	√	√	√	√	√	. .	√	. .	12
Molluscs	√	√	√	√	√	√	. .	√	√	√	√	. .	√	. .	11
Protozoa	√	√	√	√	√	√	√	√	√	√	√	√	√	√	14
Simple metazoa	√	√	√	. .	√	√	. .	√	. .	√	√	. .	√	√	10
Amphibians	√	√	√	√	√	. .	√	√	√	√	√	√	√	√	13
Fishes	√	√	√	√	√	√	√	√	. .	√	√	√	√	√	13
Reptiles	√	√	. .	√	√	. .	. .	√	. .	√	√	. .	. .	. .	7
Birds	√	√	√	√	√	√	√	√	√	√	√	√	√	√	14
Mammals	√	√	√	√	√	√	√	√	√	√	√	. .	√	√	13
Classification of animals	√	. .	. .	√	√	√	. .	. .	. .	√	√	. .	√	√	8
Animal breeding	√	√	√	√	√	. .	√	√	. .	. .	√	. .	. .	√	9
Life Processes	√	√	√	√	√	√	√	√	√	√	√	√	. .	√	13
Economics of invertebrates	. .	√	√	√	√	√	√	√	√	√	√	√	√	√	13
Economics of vertebrates	. .	√	√	√	√	√	√	√	√	√	√	√	√	√	13
Total number of topics	14	15	14	15	16	13	12	14	11	15	16	9	13	13	190

Section C: Human Biology

TOPICS	COURSES OF STUDY														
	1 Arkansas	2 Colorado	3 Idaho	4 Indiana	5 Kansas	6 Maryland	7 Missouri	8 New Jersey	9 New York	10 Oklahoma	11 Texas	12 Virginia	13 Washington	14 Wyoming	15 Total
Structure	√	√	√	√	. .	√	√	. .	√	√	. .	√	√	√	11
Foods	. .	√	√	√	√	√	√	√	√	√	√	√	√	√	13
Digestion	. .	√	√	. .	√	√	√	√	√	√	√	√	√	√	12
Respiration	. .	. .	. .	√	√	. .	√	√	√	√	√	. .	√	√	9
Circulation	. .	√	√	. .	√	√	√	√	√	√	√	. .	. .	√	10
Nervous system	. .	√	. .	√	√	√	√	√	√	√	√	. .	. .	√	10
Excretion	. .	√	. .	. .	√	. .	√	√	√	. .	√	. .	. .	√	7
Health	√	√	√	√	√	√	√	√	√	√	√	√	√	√	14
Stimulants, narcotics and drugs	√	. .	. .	√	√	√	√	√	. .	√	. .	√	. .	√	9
Total number of topics	3	7	5	6	8	7	9	8	8	8	7	5	5	9	95

TABLE X—*Continued*

Section D: Miscellaneous Topics

Introductory material	√	√	√	√	√	√	√	√	√	√	√	√	√	√	14
Heredity and evolution	√	√	√	√	..	..	√	√	..	..	√	..	√	√	9
Biography	√	√	√	√	..	√	√	√	..	√	√	..	√	√	11
Total number of topics	3	3	3	3	1	2	3	3	1	2	3	1	3	3	34

symbiosis, classification of animals, animal breeding, excretion, and heredity and evolution. It is significant that these topics similarly received little consideration in textbooks and in teachers' final examination questions.

The topics found common to all state courses of study shown in Table X are for Section A: seeds, roots, stems, leaves, plant physiology, flowers, fruits, bacteria, and economics of plants; for Section B: insects, protozoa, and birds; for Section C: health; and for Section D: introductory material. Every one of these topics is included in the courses of study of each state listed in Table X.

B. Courses of Study in Public Secondary Schools

Forty-four courses of study were received from twenty-nine states and the District of Columbia. These courses were analyzed in order to ascertain the plan of organization of biology work and the content of subject matter. Principals of two public secondary schools in each state were requested to send outlines of the biology work in their schools. Seventy-eight responses were received. The number of courses of study obtained was forty-four. Fourteen principals reported that biology was not offered in their schools and eight responded that "the course of study for biology was not in print." Twelve principals stated that their courses in biology were based on the textbooks used in their schools. Table XI deals with the courses of study submitted by principals of secondary schools in various parts of the country. The reports indicated that most of these courses were prepared by committees of teachers. The work to be done was concrete and carefully outlined. Only fourteen state courses of study out of thirty-two contained definite suggestions relative to the content for biology, while in the school courses of study,

TABLE XI

COURSES OF STUDY IN BIOLOGY FOR SECONDARY SCHOOLS SUBMITTED BY SCHOOL PRINCIPALS

STATES	COURSE OUTLINED IN TWO UNITS*	COURSE OUTLINED IN A SINGLE UNIT	REPORT "BIOLOGY NOT OFFERED"	REPORT "NO COURSE OF STUDY IN PRINT"	REPORT "TEXT BOOKS FOLLOWED"	NO REPLY
Alabama	1			1		
Arizona			1			1
Arkansas			1	1		
California	1	1				
Colorado	2					
Connecticut				1		1
Delaware				1		1
Florida				1	1	
Georgia					1	1
Idaho	2					
Illinois	1				1	
Indiana	1		1			
Iowa					1	1
Kansas		1		1		
Kentucky			1		1	
Louisiana			1		1	
Maine			1			1
Maryland	2					
Massachusetts	2					
Michigan	2					
Minnesota					1	1
Mississippi	1					1
Missouri				1	1	
Montana	1					1
Nebraska	1					1
Nevada			2			
New Hampshire	1		1			
New Jersey		1				1
New Mexico	1		1			
New York	1	1				
North Carolina	2					
North Dakota	2					
Ohio					1	1
Oklahoma	2					
Oregon	1					1
Pennsylvania	2					
Rhode Island			2			
South Carolina			1		1	
South Dakota	1					1
Tennessee	2					
Texas	2					
Utah						2
Vermont						2
Virginia	2					
Washington	1		1			
West Virginia	1			1		
Wisconsin		1			1	
Wyoming					1	1
Washington, D. C.	1					
Total	39	5	14	8	12	19

* The units are (1) plant biology and (2) animal and human biology.

the work to be done is most cases was very definitely described. Of the forty-four courses of study analyzed, thirty-nine were definitely arranged as plant biology and animal and human biology. Eleven of the fourteen state courses of study suggested a similar treatment for the content of secondary school biology (see page 39).

The texts indicated as A, B, and E in Table III are those used in schools which report that their courses in biology follow specific textbooks. Incidentally, the table of contents found in these texts is in close agreement with the majority of the school courses of study.

Courses of study for secondary school biology work was received from schools in the following 44 cities representing 29 states and the District of Columbia:

Albuquerque, N. M	Guthrie, Okla.
Ann Arbor, Mich.	Harrisburg, Pa.
Annapolis, Md.	Hastings, Neb.
Asheville, N. C.	Jersey City, N. J.
Baltimore, Md.	Kansas City, Kan.
Berkeley, Calif.	La Grande, Ore.
Biloxi, Miss.	Los Angeles, Calif.
Birmingham, Ala.	Milwaukee, Wis.
Bismarck, N. D.	Nashville, Tenn.
Boston, Mass.	New York, N. Y.
Boulder, Colo.	Pittsburgh, Pa.
Brookline, Mass.	Pocatello, Idaho
Chattanooga, Tenn.	Portsmouth, Va.
Chicago, Ill.	Rochester, N. Y.
Claremont, N. H.	Salmon, Idaho
Dallas, Texas	Seattle, Wash.
Denver, Colo.	Sioux Falls, S. D.
Detroit, Mich.	South Bend, Ind.
Elkins, W. Va.	Staunton, Va.
Fort Worth, Texas	Tulsa, Okla.
Grand Forks, N. D.	Washington, D. C.
Great Falls, Mont.	Winston-Salem, N. C.

The distribution of subject matter as represented by these courses of study is shown in Table XII. The subject matter

outlined is similar to the work recommended in the state courses of study (Table X), to the analysis of the content of textbooks (Table III), and to the analysis of the material used in teachers' final examination questions (Table VII). It is interesting to note that such topics as plant breeding, lower forms of plants, soil, conservation of plants, classification of plants, simple metazoa, reptiles, classification of animals, animal breeding, and heredity and evolution, received very little consideration in the courses of study reported by schools as compared with the emphasis placed upon the other topics. It was shown in Tables III, VII, VIII, and X, which presented the analysis of (1) textbooks (2) teachers' final examination questions (3) examination questions of the College Entrance Examination Board and of the Board of Regents for the State of New York and (4) state courses of study, respectively, that most of the topics listed are essentially in agreement as to the nature of the material and the number of topics covered. The topics found common in the majority of the courses of study for the schools reporting are: Section A: seeds, roots, stems, forestry, leaves, plant physiology, flowers, fruits, and bacteria; Section B: insects, crustaceans, worms, amphibians, birds, life processes, and the economics of invertebrates and vertebrates; Section C: structure, foods, digestion, circulation, nervous system, health, and stimulants, narcotics, and drugs; and Section D: introductory material.

In the state courses of study and the school courses of study as in textbooks, the writer finds that courses of study make rather uniform provision for the topics of plant biology, animal biology, human biology, and miscellaneous topics of biology. There are 17 topics in Section A: Plant Biology, 16 topics in Section B; Animal Biology, 9 topics in Section C; Human Biology, and 3 topics in Section D; Miscellaneous Topics of Biology.

Tables X and XII show the topics that are most commonly taught, but they do not show any per cent of the total content of the course which is devoted to any one of the topics. Their findings, therefore, are not comparable, in a mathematical way, with the results of the other four criteria. The data of these

tables, X and XII, served the writer as additional criteria upon which to base the items of the tests because, they are essentially in agreement with the findings of the analysis previously made of textbooks, of teachers' final examination questions, and of questions asked by the College Entrance Examination Board and by the Board of Regents for the State of New York, respectively.

Table XIII of Chapter III, following, gives a composite picture of the data presented in the small tables of the first three sections of this chapter. It shows the values assigned to the specific topics of biology, in rank order, in the analysis of textbooks, of teachers' final examination questions, of College Entrance Examination Board questions, and of Board of Regents questions. The table is reserved for Chapter III because, in that chapter the determining influences that these analyses had upon the selection of the items in the preliminary organization of the tests is discussed.

The fourth section of this chapter, covering the analysis of courses of study, both state and city, is not included in the composite table because the findings are of such nature as to be mathematically impossible of inclusion in apportioning the topics, as was done with the data of the first three sections. The fourth section serves as a check upon the number and nature of the topics, mainly in outline form, and the findings are, therefore, confirmatory rather than contributory.

Diagram I shows the emphasis placed upon the various topics of biology in textbooks, in teachers' final examination questions, in College Entrance Examination Board questions, and in the Board of Regents examination questions. The numbers on the base line of this diagram refer to the topics as indicated in the legend. These topics are identically the same as covered in the first three sections of this chapter. The heights of the columns show the per cents of the total content of the biology course which is devoted to each topic. Thus, under the topic of health, textbooks devote 9.10 per cent, teachers'

final examination questions 3.87 per cent, College Entrance Examination Board Questions 5.67 per cent, and Board of Regents examination questions 11.19 per cent. Among the topics which received the greatest emphasis in the four sources were: health, plant physiology, insects, life processes of animals, foods and seeds. Some of the topics scarcely treated at all were plant breeding, conservation of plants, molluscs, reptiles, simple metazoa, worms and stimulants, narcotics and drugs. This diagram is significant in that it indicates a general agreement in the amount of emphasis that the four sources placed upon most of the topics of biology.

Summary

1. Of the fourteen textbooks of biology reported by heads of the state department of education, secondary school principals, and biology teachers to be used in the public secondary schools of the United States, seven are used extensively. An analysis was made of these seven texts in order to determine the general plan of organization of biological material, the content of subject matter, and the arrangement of the topics. Table III shows the content of this analysis. This table also indicates the topics which received the greatest amount of emphasis as well as those that received the least.

2. Five of the seven textbooks which were analyzed were found to be arranged according to the separate biological sciences namely, plant biology, animal biology, and human biology. Three topics which are very general in nature and apply equally to each of the main divisions of the subject are grouped under miscellaneous material. The other two texts have the work arranged as a general course so plant and animal life are taken together as a unit. These texts were not reported to be used as extensively as the five which were arranged in the separate biological sciences.

3. The writer found that the forty-five topics listed in Table III are those commonly accepted and used by authors of biology textbooks, and they form the bases of the recommendations of state and city courses of study. These topics are distributed

as follows: 17 for plant biology, 16 for animal biology, 9 for human biology, and 3 for miscellaneous material.

4. Final examination questions were received from biology teachers in 142 public secondary schools located in 45 states. These questions were analyzed in order to ascertain the actual content of biology work throughout the country by this means. Large city, medium-sized city, and small city high schools are represented.

5. Table VII shows the distribution of the examination questions according to the topics covered. It will be noted in this table that of the 9052 questions analyzed, 3486 or 38.44 per cent were devoted to plant biology, 2902 or 32.01 per cent to animal biology, 1944 or 21.49 per cent to human biology and 720 or 8.06 per cent to miscellaneous biology material.

6. Table VIII presents an analysis of 371 examination questions for the College Entrance Examination Board, and 876 for the Board of Regents for the State of New York. Most of the topics listed in this table which were stressed as well as those which received little consideration were similarly emphasized in the analysis of textbooks and teachers' final examination questions.

7. Thirty-two state courses of study were examined in order to determine what consideration the content of biology is receiving from departments of education. Only fourteen of these courses of study contained topical outlines. The others consisted merely of aims, methods, and general suggestions. Table IX deals with the courses of study provided by states throughout the country. Courses of study which do not contain topical outlines confine themselves largely to the recommendations as laid down in Bulletin No. 26, Reorganization of Science in the Secondary Schools, of the United States Bureau of Education by the Commission on the Reorganization of Science in Secondary Schools.

8. Eleven of the fourteen definitely outlined courses of study had the work arranged as plant biology and animal and human biology. The distribution of subject matter as represented by the fourteen state courses of study that contained topical outlines for biology work is shown in Table X.

9. The organization of biology work and the content of subject matter for individual secondary schools was indicated in forty-four courses of study from twenty-nine states. The work to be done was concrete and carefully outlined and reports indicated that most of these courses were prepared by committees of teachers. Of the forty-four school courses of study analyzed, thirty-nine were definitely arranged as plant biology and animal and human biology.

10. The distribution of subject matter represented by these courses of study is shown in Table XII. The subject matter outlined is similar to the work recommended in the state courses of study, to the analysis of the content of textbooks, and to the material used in examination questions.

11. Diagram 1 shows graphically the stress placed upon the various topics of biology in textbooks, teachers' final examination questions, College Entrance Examination Board questions, and Board of Regents examination questions.

III

The Preliminary Testing

(*First and Second Try-outs*)

1. *Selection of Test-Items*

In the present stage of educational advancement there are two types of examinations in general use known as the traditional essay type and the "new type" or objective examinations, including standardized tests and scales. The former are considered as measuring achievement in a subjective manner, while the latter are intended to measure achievement in a more objective and definite manner.

The subject of new type examinations has been treated extensively in late years by a number of educational authorities.[1] Ruch has classified the main types of objective examinations as follows:

I. Recall Types:
   1. Simple recall questions.
   2. Completion exercises.

II. Recognition Types:
   1. Multiple response.
   2. True-false.
   3. Best answer.
   4. Matching exercises.
   5. Identification.

Each type has its own peculiar advantages and disadvantages, as may be seen by consultation of the authorities cited. In the construction of the biology tests under consideration, the two types of questions used are *simple recall* and *multiple response* because, *factual knowledge* for the most part is measured and

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[1] Ruch, G. M., *The Improvement of the Written Examination*. Scott, Foresman and Company, 1924.
Russell, Charles, *Classroom Tests*, Ginn and Company, 1926.
Ruch, G. M. and Stoddard, George D., *Tests and Measurements in High School Instruction*. World Book Company, 1927.

these types of questions are better adapted to that purpose.[2] The advantages of the simple recall questions are that they are relatively free from the effects of chance or guessing, and they are better adapted, perhaps, to thought questions than many other forms. The multiple response type questions are purely objective in scoring, may be very rapidly scored, can be used as a judgment test, and guessing can be minimized by using from four to seven responses.

In the selection of test-items the attempt was definitely made to follow the normal curve of distribution which is possibly best explained by the following quotation from Thorndike[3]: "It has been commonly assumed, whenever test or tasks have been scaled for difficulty in a group of given educational status, that the form of the distribution of intellect within such a group was truly represented by the Normal or Gaussian Curve." This basis for statistical procedure is further confirmed by such writers in measuring special abilities as Rugg,[4] McCall,[5] Ayres,[6] Monroe,[7] Buckingham,[8] and Trabue.[9] According to this assumption one would expect to find that most of the pupils in a given grade in school will solve about the same number of test-items and that the scores made will cluster about the median or average of the group. Further, it would be expected that a relatively small number of pupils will solve more than the average number of test-items and, likewise, only a few who will solve less than the average number. In other words, it is to be expected that the achievement of pupils will be distributed

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[2] Ruch, G. M. and Stoddard, George D., *Tests and Measurements in High School Instruction*, Chapter XV, World Book Company, 1927.

[3] Thorndike, Edward L., and others, *The Measurement of Intelligence*, Bureau of Publications, Teachers College, Columbia University, 1925.

[4] Rugg, Harold C., *Statistical Measurements Applied to Education*, Houghton Mifflin Company, 1917.

[5] McCall, William A., *How to Measure in Education*, The MacMillan Company, 1922.

[6] Ayres, L. P., *Measurement of Ability in Spelling*, Russell Sage Foundation, 1915.

[7] Monroe, Walter S., *An Introduction to the Theory of Educational Measurements*, Houghton Mifflin Company, 1923.

[8] Buckingham, B. R., *Spelling Ability, Its Measurement and Distribution*, Columbia University Contributions to Education No. 59, 1913.

[9] Trabue, M. R., *Completion—Test Language Scales*, Columbia University Contribution to Education No. 77, 1916.

symmetrically on each side of the average. In the development of these biology tests, the items were selected to fall under five groupings: very easy, easy, average, difficult, and very difficult.

Several prominent writers[10] in the field of tests and measurements agree upon certain fundamental steps that should be followed in the selection of test-items and in the construction of a test. The general plan for constructing an objective test as suggested by Ruch[11] in "The Improvement of the Written Examination" is as follows:

"1. Decide upon the exact scope of the proposed test. Make a list of the most important topics falling within the limits selected.

"2. Take the topics selected and think out very carefully the most significant facts falling under each topic.

"3. Arrange the questions under each topic, as far as possible, in the order of difficulty.

"4. Devise a large number of questions, from fifty to one hundred per cent more than will be included in the final test, in order that only the best will be selected for the final form.

"5. Turn the questions into the type that is most appropriate for the material at hand.

"6. Decide the length of the test and the time that will be required for administering it.

"7. From the items under each topic, select on the basis of importance and difficulty those that may be used in the time allotted for the test.

"8. Give the preliminary list of items to a large number of pupils and on the basis of the results select the items for the final form."

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[10] McCall, William A., *How to Measure in Education*, The MacMillan Company, 1922.
Ruch, G. M., *The Improvement of the Written Examination*, Scott, Foresman and Company, 1924.
Monroe, Walter S., *An Introduction to the Theory of Educational Measurements*, Houghton Mifflin Co., 1923.
Symonds, P. M., *Measurement in Secondary Education*, The MacMillan Company, 1927.
Pressey, S. L., *Introduction to the Use of Standard Tests*, World Book Company, 1922.
Trabue, M. R., *Measuring Results in Education*, The American Book Company, 1924.

[11] *Ibid.*, pp. 96–99.

The following five principles from Chapman[12] were adopted as the requirements that each test-item must fulfill in order that it might be suitable for the purposes of objective measurement:

"1. It must apply specifically to the field of knowledge for which the test is constructed.

"2. It must be taken from an essential part of the subject which is contributory to understanding or summarizing a general theory or principle. The question, in other words, should be such that a correct answer would indicate that a distinct meaning has been grasped.

"3. It should be so worded as not to be ambiguous.

"4. It must be so framed that it can be answered very concisely, usually in a single word or at most by a short sentence.

"5. It must be such that the short answer given in the test includes all possible correct answers."

Naturally these very general principles have to be amplified and the methods refined in the construction of a standardized objective test.

The first step in the construction of these biology tests was the assembling of a large number of test-items or questions in accord with the above mentioned principles. Fifteen hundred test-items were devised, nine hundred of the simple recall type and six hundred of the multiple response. These questions were based upon the data described in Chapter II, namely, an analysis of textbooks, teachers' final examination questions, College Entrance Examination Board questions, questions of the Board of Regents for the State of New York, and the recommendations of state and city courses of study.

These 1500 test-items were submitted to nineteen biology teachers for criticism.[13] The names of these teachers were not asked for, as it was thought that possibly more impartial judgments might be received if they remained anonymous. The instructions sent to the teachers were as follows:

1. Write (S) after each test-item you consider entirely satisfactory and

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[12] Chapman, J. C., *The Measurement of Physics Information*, School Review, XXVIII, Dec., 1919, pp. 748–756.

[13] See Appendix II for a list of cities in which these teachers were located.

representative of the biology material secondary school pupils, second year or tenth grade, should be able to answer.

2. Write (N.S.) after each test-item you consider unsatisfactory and not representative of the material for second year or tenth grade pupils in secondary school biology.

3. Write (A) after each test-item that is ambiguous.

4. Write (E) after each test-item that should be eliminated—too difficult or too easy.

5. Write any pointed comment that may occur to you after each test-item.

A detailed study of the replies obtained from the biology teachers showed that in their judgment 270 test-items were too difficult, 211 were too easy, and 130 were ambiguous. This careful scrutiny of the 1500 original test-items resulted in the elimination of those which were considered unsatisfactory. A total of 889 items remained. These 889 items were, therefore, suitable in the estimation of teacher critics.

There is, however, another important factor to be considered. Questions may be judged suitable by teachers and yet not be adapted to the pupils who are to take the test. To ascertain actual pupil reaction to the items passed as satisfactory by the teachers, the 889 items were arranged in a series of tests and the first try-out was given in twelve secondary school classes to 418 pupils. It was found that many of the items were still too difficult or too easy, in other words, that too many test-items were passed or failed by a large number of pupils. So the most objectionable were removed and 602 items passed as satisfactory both by teacher judgments and pupil reactions. From these 500 were selected for the preliminary forms of the test, second try-out.

The proportional value of each sub-division of the subject was determined by rankings made from an analysis of textbooks, teachers' final examination questions, College Entrance Examination Board questions, and Board of Regents questions. These sources were given the greatest weight in the selection of the test-items. Textbooks were selected as one of the bases because they furnish the teacher a tangible body of material which is generally considered most important and suitable for purposes of instruction. Teachers' final examination ques-

tions were used as a second basis because they revealed the topics which, in the estimation of teachers giving the course, are most fundamental. Questions of the College Entrance Examination Board and of the Board of Regents were used as the third and fourth bases, respectively, because they indicate those topics of biology which the examining boards considered most important and included most frequently. The personnel of the examining boards is in itself evidence of the care and thoroughness that is exercised in formulating the questions. State courses of study and city courses of study were used as a guide in selecting the test-items since they show the plan of organization of biology work and the nature of the materials to be covered.

The arithmetical averages of the per cents of the total content which were devoted to the various topics of biology in textbooks, teachers' final examination questions, College Entrance Examination Board Questions, and Board of Regents questions were found and, using these averages as a basis, proportional values were assigned to each topic.

Table XIII gives this list of values, their rank, and the corresponding number and per cent of test-items selected. For example, under the topic of health, textbooks devote 9.10 per cent, teachers' final examination questions 3.87 per cent, College Entrance Examination Board questions, 5.67, and Board of Regents questions 11.19. The arithmetical average of the four is 7.46. This is a value for the particular topic of health. All of the topics were treated in a similar way and specific values were found for each. It will be noted in Table XIII that the number and per cent of test items selected is within the limits of the values assigned to most of the topics. There are a few cases, however, where the per cent of test-items selected from certain topics exceeds the values assigned to them. Thus, under the topic of flowers, the value assigned is 2.91 and the per cent of test-items selected is 3.40. This increase represents the effect of the state and city courses of study (Tables X and XII, Chapter II), and is an arbitrary increase justified by the fact that the topic (flowers) is included in one hundred per cent of both state and city courses of study. Likewise, for the other

TABLE XIII

VALUE ASSIGNED TO SPECIFIC TOPICS OF BIOLOGY IN RANK ORDER IN THE PRELIMINARY TEST, SECOND TRY-OUT, AND CORRESPONDING NUMBER AND PER CENT OF TEST-ITEMS SELECTED

	1	2	3	4	5	6	7	8
TOPICS	PER CENT OF TOTAL SPACE DEVOTED TO EACH TOPIC IN SEVEN TEXTBOOKS	PER CENT OF TOTAL NUMBER OF TEACHERS' FINAL EXAMINATION QUESTIONS	PER CENT OF TOTAL NUMBER OF COLLEGE ENTRANCE EXAMINATION BOARD QUESTIONS	PER CENT OF TOTAL NUMBER OF BOARD OF REGENTS EXAMINATION QUESTIONS	VALUE (ARITHMETICAL AVERAGE OF COLUMNS 1, 2, 3, AND 4)	RANK	NUMBER OF TEST-ITEMS SELECTED	PER CENT OF TEST-ITEMS SELECTED
Health	9.10	3.87	5.67	11.19	7.46	1	36	7.20
Plant physiology	3.69	4.63	7.29	6.39	5.31	2	26	5.20
Insects	7.04	5.71	2.69	3.76	4.80	3	32	6.40
Foods	5.87	3.42	4.58	4.84	4.68	4	23	4.60
Seeds	2.62	4.61	4.58	5.82	4.41	5	21	4.20
Life processes (animals)	3.04	2.47	5.93	5.49	4.23	6	16	3.20
Introductory material	3.68	2.98	4.58	3.87	3.77	7	18	3.60
Circulation (Human biology)	3.05	3.10	.81	4.34	2.94	8	14	2.80
Flowers	2.93	4.43	1.08	3.19	2.91	9	17	3.40
Stems	1.85	3.91	1.89	3.65	2.83	10	14	2.80
Cells	1.55	2.54	4.04	2.96	2.77	11	12	2.40
Birds	3.70	2.95	.81	3.54	2.75	12	13	2.60
Roots	1.48	2.85	4.04	2.40	2.69	13	12	2.40
Amphibians	2.27	2.12	3.23	2.85	2.62	14	11	2.20
Fishes	2.15	2.79	3.77	1.37	2.55	15	13	2.60
Structure (Man)	2.20	2.84	2.69	2.17	2.48	16	13	2.60
Leaves	2.49	2.53	1.62	3.19	2.46	17	12	2.40
Digestion (Human biology)	2.85	2.30	1.08	3.54	2.44	18	12	2.40
Nervous System (Human biology)	4.32	2.31	2.69	.23	2.39	19	12	2.40
Bacteria	1.94	2.22	2.69	2.62	2.37	20	12	2.40
Economics of Invertebrates	1.46	2.01	3.23	2.28	2.23	21	11	2.20
Protozoa	1.30	2.26	2.69	1.94	2.05	22	10	2.00
Crustaceans	1.48	2.41	1.62	2.62	2.03	23	10	2.00

TABLE XIII—*Continued*

TOPICS	1 PER CENT OF TOTAL SPACE DEVOTED TO EACH TOPIC IN SEVEN TEXTBOOKS	2 PER CENT OF TOTAL NUMBER OF TEACHERS' FINAL EXAMINATION QUESTIONS	3 PER CENT OF TOTAL NUMBER OF COLLEGE ENTRANCE EXAMINATION BOARD QUESTIONS	4 PER CENT OF TOTAL NUMBER OF BOARD OF REGENTS EXAMINATION QUESTIONS	5 VALUE (ARITHMETICAL AVERAGE OF COLUMNS 1, 2, 3, AND 4)	6 RANK	7 NUMBER OF TEST-ITEMS SELECTED	8 PER CENT OF TEST-ITEMS SELECTED
Economics of plants	1.80	1.98	2.43	1.71	1 98	24.5	9	1.80
Lower forms of plants	1.46	1.90	3.77	.80	1.98	24.5	9	1.80
Heredity and evolution	2.55	2.85	2.43	....	1.96	26	10	2.00
Fruits	1.17	2.42	2.43	1.14	1.79	27	9	1.80
Respiration (Human biology)	2.44	1.26	1.35	1.26	1.58	28	8	1.60
Mammals	2.46	1.64	1.62	.57	1.58	29	7	1.40
Forestry	2.50	.93	.54	1.94	1.48	30	7	1.40
Symbiosis	1.06	.66	2.16	1.83	1.43	31	7	1.40
Economics of vertebrates	.79	1.29	1.35	1.83	1.32	32	7	1.40
Classification of animals	.89	1.97	1.89	....	1.19	33	6	1.20
Soil	1.18	1.14	1.08	1.26	1.17	34	6	1.20
Biography	.56	2.23	1.35	.23	1.09	35	8	1.60
Stimulants, narcotics, and drugs	1 90	1.52	....	.80	1.06	36	7	1.40
Excretion (Human biology)	1.12	.87	.54	1.14	.92	37	4	.80
Classification of plants	.81	.89	1.89	....	.90	38	4	.80
Conservation of plants	.98	.51	.54	.91	.73	39	3	.60
Worms	.76	1.54	....	.11	.60	40	5	1.00
Simple metazoa	.68	.91	.54	....	.53	41	4	.80
Molluscs	.38	.88	.81	.11	.51	42	2	.40
Plant breeding	1.13	.29	....	.11	.38	43	3	.60
Reptiles	.62	.80	....	....	.36	44	3	.60
Animal breeding	.70	.26	....	.11	.27	45	2	.40

few cases, arbitrary adjustment was made because of the stress given to them by the state and city courses of study.

The test-items were arranged in separate tests for (1) plant biology and (2) animal and human biology with parts I and II for each. The tests were drawn up in accordance with the principles which were referred to previously in this chapter and included:

TEST 1

PLANT BIOLOGY

Part I—Simple recall.....150 items
Part II—Multiple responses.....100 items

TEST 2

ANIMAL AND HUMAN BIOLOGY

Part I—Simple recall.....150 items
Part II—Multiple response.....100 items

2. *Preliminary Testing*

The preliminary tests, second try-out, were given to 1248 pupils in eleven public secondary schools, eight of which were in Pennsylvania, one in New Jersey, one in Delaware, and one in Virginia. The schools selected represented cities of various sizes ranging from 100,000 population and over to under 25,000. The pupils given the tests were in the tenth grade or second year of the high school. Of the tests completed and returned, 500 were for Test 1 and 506 for Test 2. The difference between this number and the number of tests sent out is accounted for by absence of pupils and incomplete test papers. One thousand papers were considered adequate for the purpose of the preliminary testing, so 6 were discarded for Test 2 in order that the results for the two tests could be based upon the same number of pupil responses.

All of the tests were given during the week beginning June 7, 1926. Every detail concerning the administering of the tests was carefully planned and detailed instructions were given those in charge of the testing in order that the testing conditions might be as uniform as possible.[14] The time allowed for Part

[14] A copy of these instructions may be found in Appendix IV.

I of each test was ninety minutes, and for Part II of each test 40 minutes. Parts I and II of the tests were given on different days. It was felt that it was important that each pupil should have a chance to attempt each item. Reports from teachers who gave the tests showed that all pupils finished in the time that was allowed.

In tabulating the results, all test-items were regarded as having equal value and were counted as right or wrong. The tests were scored either by the writer himself or under his direct supervision, thus reducing the personal element in marking to a minimum. Since each test-item had the same value, the standard of scoring was quite simple. Only the items correct were checked. The total number of correct responses for each item on all the papers was counted and the percentage of the pupils who did each test-item correctly was computed. These results are given in Tables XIV, XV, XVI and XVII. The percentages obtained may be called the per cent score for each item. Some of the items were done correctly by nearly 100 per cent of the pupils, while others were done incorrectly by nearly 100 per cent.

TABLE XIV

NUMBER AND PER CENT OF PUPILS THAT SOLVED EACH TEST-ITEM CORRECTLY IN TEST 1, PART I—PLANT BIOLOGY

Item Number	Number Correct	Per Cent Correct	Item Number	Number Correct	Per Cent Correct	Item Number	Number Correct	Per Cent Correct	Item Number	Number Correct	Per Cent Correct
1	497	97.4	38	422	84.4	75	234	46.8	113	90	18.0
2	490	98.0	39	350	70.0	76	231	46.2	114	164	32.8
3	484	96.8	40	337	67.4	77	192	38.4	115	102	20.4
4	498	99.6	41	428	85.6	78	178	35.4	116	135	27.0
5	479	95.8	42	412	82.4	79	207	41.7	117	124	24.8
9	467	93.4	43	394	78.8	80	199	39.8	118	155	31.0
7	497	99.4	44	369	73.8	81	242	48.4	119	67	13.4
8	494	98.8	45	417	83.4	82	174	34.8	120	146	29.2
9	486	97.2	46	339	67.9	83	203	40.6	121	86	17.2
10	488	97.6	47	278	75.6	84	192	38.4	122	120	24.0
11	456	91.2	48	399	79.8	85	253	50.6	123	57	11.4
12	471	94.2	49	362	73.6	86	272	54.4	124	37	7.4
13	441	88.2	50	354	70.8	87	245	49.0	125	24	4 8
14	462	92.4	51	284	56.8	88	224	44.8	126	54	10.8
15	482	96.4	52	269	53.8	89	184	36.8	127	20	4.0
16	450	90.0	53	305	61.0	90	138	27.6	128	46	9.2
17	436	87.2	54	319	63.8	91	159	31.8	129	12	2.4
18	477	95.4	55	322	64.4	92	114	22.8	130	75	15.0
19	479	95.8	56	291	58.2	93	132	26.4	131	4	.8
20	454	90.8	57	301	60.2	94	234	46.8	132	95	19.0
21	439	87.8	58	312	62.4	95	117	23.4	133	127	25.4
22	465	93.0	59	259	51.8	96	239	47.9	134	82	16.4
23	420	84.0	60	255	51.0	97	221	44.2	135	8	1.6
24	389	77.8	61	264	52.8	98	140	28.0	136	114	22.8
25	359	71.8	62	316	63.2	99	99	19.8	137	71	14.2
26	343	68.6	63	251	50.2	100	276	55.2	138	79	15.8
27	405	81.0	64	261	52.2	101	247	49.4	139	2	.4
28	444	88.8	65	218	43.6	102	227	45.4	140	2	.4
29	474	94.8	66	333	66.6	103	151	30.2	141	79	15.8
30	384	76.8	67	280	56.0	104	170	34.0	142	50	10.0
31	408	81.6	68	259	51.8	105	195	39.0	143	63	12.6
32	459	91.8	69	297	59.4	106	108	21.6	144	3	.6
33	424	84.8	70	189	37.8	107	237	47.4	145	29	5.8
34	433	86.8	71	326	65.2	108	212	42.4	146	1	.2
35	374	74.8	72	308	61.6	109	181	36.2	147	42	8.4
36	347	69.4	73	287	57.4	100	90	18.0	148	67	13.4
37	366	73.2	74	234	46.8	111	129	25.8	149	17	3.4
						112	111	22.2	150	33	6.6

TABLE XV

NUMBER AND PER CENT OF PUPILS THAT SOLVED EACH TEST-ITEM CORRECTLY IN TEST 1, PART II—PLANT BIOLOGY

Item Number	Number Correct	Per Cent Correct	Item Number	Number Correct	Per Cent Correct	Item Number	Number Correct	Per Cent Correct	Item Number	Number Correct	Per Cent Correct
1	486	97.2	26	426	85.2	51	198	39.6	76	244	48.8
2	491	98.2	27	412	82.4	52	159	31.8	77	231	46.2
3	452	90.4	28	403	80.6	53	227	45.4	78	189	37.8
4	497	99.4	29	271	54.2	54	147	29.4	79	177	35.4
5	492	98.4	30	317	63.4	55	148	49.4	80	162	32.4
6	482	96.4	31	391	78.2	56	171	34.2	81	69	13.8
7	495	99.0	32	248	69.6	57	213	42.6	82	132	26.4
8	467	93.4	33	296	59.2	58	116	23.2	83	36	7.2
9	499	99.8	34	327	65.4	59	81	16.2	84	63	12.6
10	446	89.2	35	353	70.6	60	236	47.4	85	94	18.8
11	488	97.6	36	376	75.2	61	204	40.8	86	122	24.4
12	417	83.4	37	261	52.2	62	254	50.8	87	4	.8
13	432	86.4	38	282	56.6	63	152	30.4	88	19	3.8
14	477	95.4	39	336	67.2	64	141	28.2	89	76	15.2
15	457	91.4	40	361	72.2	65	183	36.6	90	88	17.6
16	472	94.4	41	378	75.6	66	218	43.6	91	111	22.2
17	396	79.2	42	278	55.6	67	241	48.2	92	25	5.0
18	443	88.6	43	322	64.4	68	51	10.2	93	2	.4
19	463	92.6	44	383	76.6	69	106	21.2	94	13	2.6
20	406	81.2	45	313	62.6	70	129	25.8	95	47	9.4
21	448	89.6	46	342	68.4	71	251	50.2	96	101	20.2
22	421	84.2	47	266	53.2	72	209	41.8	97	57	11.4
23	367	73.4	48	257	51.4	73	166	33.2	98	41	8.2
24	331	66.2	49	228	57.6	74	155	31.0	99	30	6.0
25	308	61.6	50	304	69.8	75	222	44.4	100	9	1.8

TABLE XVI

NUMBER AND PER CENT OF PUPILS THAT SOLVED EACH TEST-ITEM CORRECTLY IN TEST 2, PART I—ANIMAL AND HUMAN BIOLOGY

Item Number	Number Correct	Per Cent Correct	Item Number	Number Correct	Per Cent Correct	Item Number	Number Correct	Per Cent Correct	Item Number	Number Correct	Per Cent Correct
1	456	91.2	38	361	72.2	75	304	60.8	113	18	3.6
2	497	99.4	39	393	78.6	76	221	44.2	114	53	10.8
3	498	99.6	40	413	82.6	77	208	41.6	115	156	31.2
4	490	98.0	41	388	77.6	78	235	47.2	116	79	15.8
5	471	94.2	42	379	75.8	79	226	45.2	117	99	19.8
6	499	99.8	43	372	74.4	80	255	51.0	118	132	26.4
7	493	98.6	44	342	68.4	81	214	42.8	119	141	28.2
8	459	91.8	45	404	80.8	82	198	39.6	120	161	32.2
9	431	86.2	46	397	79.4	83	226	45.2	121	127	25.4
10	464	92.8	47	417	83.4	84	246	49.2	122	103	20.6
11	483	96.6	48	395	79.0	85	240	48.0	123	114	22.8
12	424	84.8	49	355	71.0	86	232	46.4	124	174	34.8
13	451	90.2	50	345	69.0	87	242	48.2	125	145	29.0
14	477	95.4	51	290	58.0	88	151	30.2	126	95	19.0
15	489	97.8	52	308	61.6	89	123	24.6	127	88	17.6
16	487	97.4	53	275	55.0	90	252	50.4	128	46	9.2
17	464	92.8	54	261	52.2	91	238	47.6	129	76	15.2
18	443	89.6	55	327	65.4	92	212	42.4	130	120	24.0
19	428	85.6	56	334	66.8	93	201	40.2	131	106	21.2
20	468	93.6	57	286	57.2	94	184	36.8	132	68	13.6
21	473	94.6	58	279	55.8	95	224	44.8	133	32	6.4
22	453	90.6	59	270	54.0	96	191	38.2	134	11	2.2
23	448	99.6	60	320	54.0	97	136	27.2	135	58	11.6
24	435	87.0	61	338	67.6	98	103	20.6	136	68	13.6
25	439	87.8	62	296	59.2	99	168	33.6	137	22	4.4
26	393	78.6	63	283	56.6	100	205	41.0	138	3	.6
27	364	72.8	64	257	51.4	101	217	43.4	139	2	.4
28	349	69.8	65	267	53.4	102	229	45.8	140	50	10.0
29	376	75.2	66	323	64.6	103	188	37.6	141	71	14.2
30	421	84.2	67	313	62.6	104	195	61.0	142	56	11.2
31	358	71.6	68	272	54.4	105	249	49.8	143	37	7.4
32	383	76.6	69	264	52.8	106	179	35.8	144	28	5.6
33	401	80.2	70	299	59.8	107	111	22.2	145	53	10.6
34	369	73.8	71	317	63.4	108	91	18.2	146	2	.4
35	404	80.8	72	331	66.1	109	83	16.6	147	15	3.0
36	361	72.2	73	292	58.4	110	116	23.2	148	8	1.6
37	352	70.4	74	286	57.2	111	63	12.6	149	6	1.2
						112	41	8.2	150	8	1.6

TABLE XVII

NUMBER AND PER CENT OF PUPILS THAT SOLVED EACH TEST-ITEM CORRECTLY IN TEST 2, PART II—ANIMAL AND HUMAN BIOLOGY

Item Number	Number Correct	Per Cent Correct	Item Number	Number Correct	Per Cent Correct	Item Number	Number Correct	Per Cent Correct	Item Number	Number Correct	Per Cent Correct
1	485	97.0	26	363	72.6	51	213	42.6	76	101	20.2
2	451	90.2	27	320	64.0	52	171	34.2	77	74	14.8
3	498	99.6	28	281	56.2	53	139	27.8	78	48	9.6
4	431	86.2	29	306	61.2	54	199	39.8	79	33	6.6
5	469	93.8	30	377	75.4	55	244	48.8	80	1	.2
6	498	99.6	31	334	66.8	56	176	35.2	81	24	4.8
7	441	88.2	32	267	53.4	57	130	26.0	82	121	24.2
8	493	98.6	33	293	58.6	58	157	33.4	83	36	7.2
9	487	97.4	34	346	69.2	59	227	45.4	84	7	1.4
10	413	82.6	35	368	73.6	60	239	47.8	85	125	25.0
11	491	98.2	36	252	50.4	61	162	32.4	86	94	18.8
12	393	78.6	37	273	54.6	62	220	44.0	87	60	12.0
13	478	95.6	38	338	67.6	63	134	26.8	88	108	21.6
14	425	85.0	39	352	70.4	64	191	38.2	89	30	6.0
15	474	94.8	40	247	49.4	65	204	40.8	90	54	10.8
16	463	92.6	41	326	65.2	66	223	44.6	91	94	18.8
17	400	80.0	42	359	71.8	67	235	47.0	92	114	22.8
18	458	91.6	43	373	74.6	68	146	29.2	93	3	.6
19	382	76.4	44	313	62.6	69	145	33.0	94	18	3.6
20	446	89.2	45	276	55.2	70	232	46.4	95	1	.2
21	431	86.2	46	256	51.2	71	199	39.8	96	68	13.6
22	387	77.4	47	288	57.6	72	183	36.6	97	87	17.4
23	437	87.4	48	341	68.2	73	216	43.6	98	12	2.4
24	419	83.8	49	299	59.8	74	151	31.2	99	81	16.2
25	406	81.2	50	262	52.4	75	208	41.6	100	41	8.2

Summary

1. In the construction of the tests, two types of items are used: simple recall and multiple response.

2. The test-items were selected to fall under five groupings: very easy, easy, average, difficult, and very difficult.

3. The original list of 1500 items was drawn up in accordance with the principles of test construction agreed upon by prominent writers in the field of tests and measurements. This list of items was submitted to nineteen biology teachers for criticism; 889 test-items were considered valid in the estimation of teacher critics. These items were arranged in a series of tests and given to 418 pupils in twelve secondary school classes.

4. On the basis of pupil reaction all objectionable items were eliminated and 602 were accepted as satisfactory, from which 500 were selected, for the second try-out of the tests.

5. The proportional value of each sub-division of the subject was determined by rankings made from an analysis of textbooks, teachers' final examination questions, College Entrance Examination Board questions, and Board of Regents questions. These sources were given the greatest weight in the selection of the test-items. State and city courses of study were used as a guide in selecting the test-items since they show the plan of organization of biology work and the nature of the materials covered.

6. Two tests composed of 250 items each with Forms I and II were devised for the second try-out. These tests were given to 1248 pupils in eleven public secondary schools located in four states. The tests were scored either by the writer himself or under his direct supervision. Only test-items correct were checked. The total number of correct responses for each item on all the papers were counted and the percentage of the pupils who did each correctly was computed. These results are given in Tables XIV, XV, XVI, and XVII.

IV

Construction of the Final Tests

The final step in the construction of a standardized test is that of casting the items into equivalent forms, in this case, two in number. As has been indicated in Chapter III, the final forms of the test should consist of a large number of items of average difficulty and smaller number of easy and hard items; in effect the items should follow the so-called Normal Probability Curve.

Rugg[1] gives the method of doing this in his "Statistical Methods Applied to Education." The problem is to determine the real difficulty of the items to be used in the tests. The basic assumption is that abilities in biology as in any other subject are distributed in accordance with some known distribution and so the relative degree of difficulty of each item must be discovered.[2]

The base line represents a scale of biological ability ranging from nearly zero ability, in other words no ability at all, to 100 or nearly 100 per cent ability. The area between the curve and the base line represents the number of pupils taking the preliminary forms of the test. If the base is divided into any number of parts and perpendicular lines are erected at the points representing these parts, the number of pupils that will be found between these distances on the base line can be determined from the properties of the normal curve. Rugg[3] gives a table showing the fractional parts of the total area under the normal probability curve corresponding to distances on the base line between the mean and successive points of division laid off from the mean. Point 0 on the base line is arbitrarily placed at the mean and σ distances are set off at plus and minus points from the mean. In a distribution in which the base line is broken

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[1] Rugg, Harold O., *Statistical Methods Applied to Education*, Houghton Mifflin Company, 1917, pp. 216–227.

[2] Monroe, Walter S., *An Introduction to the Theory of Educational Measurements*, p. 92, Houghton Mifflin Company, 1923.

[3] *Ibid.*, pp. 389–390.

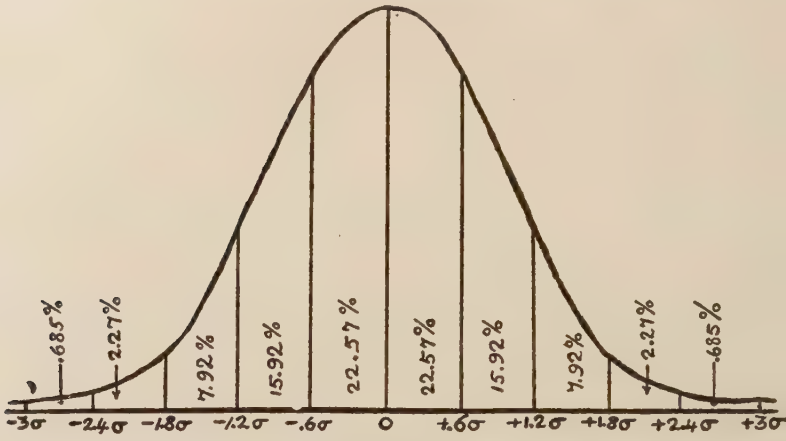

Figure 1.—Distribution of measures in ten groups under normal curve when unit length of each group equals .6σ; base line equals 6σ.

off at 3σ distances on each side of the mean in order to get ten divisions of the base line, it is necessary to take .6σ from each side of the mean, 1.2σ, 1.8σ, 2.4σ, and 3σ. Figure 1 presents the data in the particular case under discussion. Using Rugg's table it is found that between the mean ordinate 0 and an ordinate erected at 3σ is included 49.865 per cent of the entire area. Between 3σ and 2.4σ is included. 685 per cent of the entire area, between 2.4σ and 1.8σ 2.27 per cent, between 1.8σ and 1.2σ 7.93 per cent, between 1.2σ and .6σ 15.92 per cent, and between. 6σ and 0 22.57 per cent. Since the curve meets the base line only at infinity, the area included between infinity and plus 3σ is .135 per cent of the entire area. The divisions which have been discussed deal with the positive half of the base line. Since there is a negative as well as a positive half of the curve, the above figures will be true for the negative side.

So far the normal curve has been used with distances set off on the base line from a zero point erected at the theoretical mean. In applying this conception to the construction of test-items, a distribution of σ distances is required involving the computation of the percentage of total measures between 0 and any selected distance on the x-axis, ranging from end to end

instead of from the mean point to either end. The distance in this particular case is .6σ. By setting off distance on the base line from minus 3σ instead of from the theoretical mean or 0, the base line shown in Figure 1 becomes

0 .6σ 1.2σ 1.8σ 2.4σ 3.0σ 3.6σ 4.2σ 4.8σ 5.4σ 6.0σ

. . . . . .

0 is set arbitrarily at minus 3σ. Rugg[4] presents a probability table giving distances on the base line corresponding to various percentages of pupils who fail the individual items of the test. From this table of Rugg were constructed Tables XVIII and XIX of this study which are a revision of the data presented in Tables XIV and XV after the second try-out of the preliminary testing (see Chapter III). In Table XVIII the items have been rearranged in order of difficulty, based upon the results at the Preliminary testing, and remembered accordingly. For each item is shown the per cent of pupils failing, the position of each item on a percentage distribution from 0 to 100 transmuted into terms of σ values on a 6σ scale, and the percentile score. For example, item number 1 was failed by .4 per cent of the 500 pupils attempting it, item number 25 by 12.8 per cent. In the first case, according to Rugg's table, the position of item number 1 on the scale is .45, and the position of item number 25 1.87. The percentile score of the former is 7.5 and of the latter 31.17.

The same method was used for all items in determining the order of difficulty for the two tests with their equivalent forms. The plan of construction used in developing one of the tests only is necessary since the details involved are the same for each. Test 1, Forms A and B, Plant Biology, has been selected for this purpose. The data for Test 2, Forms A and B, Animal and Human Biology, are given in Appendices V and VI. These data, together with the explanations given here, will show very clearly how the other test was developed. The tests in the final form consist of:

[4] *Ibid.*, Table VI, pp. 396-400.

TABLE XVIII

PERCENTILE SCORES ASSIGNED TO EACH TEST-ITEM WHICH CORRESPOND TO VARIOUS PERCENTAGES OF PUPILS WHO FAIL TO SOLVE ITEMS, BASED UPON AREA OF PROBABILITY CURVE ASSUMING THE BASE LINE TO BE BROKEN OFF AT $\pm 3\sigma$. (TEST 1, PART I—PLANT BIOLOGY)

Item Number	Per Cent Failing	Distance x/σ	Percentile Score	Item Number	Per Cent Failing	Distance x/σ	Percentile Score	Item Number	Per Cent Failing	Distance x/σ	Percentile Score
1	.4	.45	7.50	51	33.4	2.58	43.00	101	67.2	3.44	57.33
2	.6	.56	9.33	52	34.2	2.60	43.33	102	68.2	3.47	57.83
3	1.2	.72	12.00	53	34.8	2.61	43.50	103	69.0	3.49	58.17
4	2.0	.97	16.17	54	35.6	2.63	43.67	104	69.8	3.52	58.83
5	2.4	1.05	17.50	55	36.2	2.65	44.17	105	71.8	3.57	59.50
6	2.6	1.08	18.00	56	36.8	2.67	44.50	106	72.0	3.58	59.67
7	2.8	1.11	18.50	57	37.6	2.69	44.83	107	72.4	3.59	59.83
8	3.2	1.17	19.50	58	38.4	2.71	45.33	108	73.0	3.61	60.17
9	3.6	1.22	20.33	59	39.0	2.73	45.50	109	73.6	3.63	60.50
10	4.2	1.29	21.50	60	39.8	2.75	45.85	110	74.2	3.65	60.83
11	4.2	1.29	21.50	61	40.6	2.77	46.17	111	74.6	3.66	61.00
12	4.6	1.33	22.17	62	41.8	2.80	46.67	112	75.2	3.68	61.33
13	5.2	1.39	23.17	63	42.6	2.82	47.00	113	76.0	3.69	61.50
14	5.8	1.44	24.00	64	43.2	2.84	47.33	114	76.6	3.72	62.00
15	6.6	1.51	25.27	65	44.0	2.86	47.67	115	77.2	3.74	62.33
16	7.0	1.54	25.67	66	44.8	2.87	47.83	116	77.2	3.74	62.33
17	7.6	1.58	26.33	67	45.6	2.89	48.17	117	77.8	3.76	62.67
18	8.2	1.62	27.00	68	46.2	2.91	48.50	118	78.4	3.78	63.00
19	8.8	1.66	27.67	69	47.2	2.93	48.83	119	79.6	3.82	63.67
20	9.2	1.68	28.00	70	47.8	2.95	49.17	120	80.2	3.85	64.17
21	10.0	1.73	28.83	71	48.2	2.96	49.33	121	81.0	3.88	64.67
22	11.2	1.80	30.00	72	48.2	2.96	49.33	122	82.0	3.91	65.17
23	11.8	1.82	30.33	73	49.0	2.97	49.50	123	82.0	3.91	65.17
24	12.2	1.85	30.83	74	49.4	2.98	49.67	124	82.8	3.94	65.67
25	12.8	1.87	31.17	75	49.8	2.99	49.83	125	83.6	3.97	66.17
26	13.4	1.90	31.67	76	50.6	3.01	50.17	126	84.2	4.04	67.00
27	14.4	1.94	32.33	77	51.0	3.02	50.33	127	84.2	4.04	67.00
28	15.2	1.98	33.00	78	51.6	3.04	50.67	128	85.0	4.03	67.17
29	15.6	2.00	33.33	79	52.2	3.05	50.83	129	85.8	4.07	67.87
30	16.0	2.02	33.67	80	52.6	3.06	51.00	130	86.6	4.10	68.33
31	16.6	2.04	34.00	81	53.2	3.08	51.33	131	86.6	4.10	68.33
32	17.6	2.08	34.67	82	53.2	3.08	51.33	132	87.4	4.14	69.00
33	18.4	2.11	35.17	83	53.8	3.09	51.50	133	88.6	4.20	70.00
34	19.0	2.13	35.50	84	54.6	3.11	51.83	134	89.2	4.23	70.50
35	20.2	2.17	36.17	85	55.2	3.13	52.17	135	90.0	4.27	71.17
36	21.2	2.21	36.83	86	55.8	3.14	52.33	136	90.8	4.32	72.00
37	22.2	2.24	37.33	87	56.4	3.16	52.67	137	91.6	4.37	72.87
38	23.2	2.28	38.00	88	57.6	3.19	53.17	138	92.6	4.43	73.87
39	24.4	2.31	38.50	89	58.6	3.21	53.50	139	93.4	4.50	75.00
40	25.2	2.34	39.00	90	59.4	3.24	54.00	140	94.2	4.56	76.00
41	26.2	2.37	39.50	91	60.2	3.26	54.33	141	94.2	4.56	76.00
42	26.8	2.38	39.67	92	61.0	3.28	54.67	142	96.0	4.73	78.87
43	27.6	2.41	40.17	93	61.6	3.29	54.83	143	96.6	4.82	80.33
44	28.2	2.43	40.50	94	61.6	3.29	54.83	144	97.6	4.96	82.67
45	29.2	2.46	41.00	95	62.2	3.31	55.17	145	98.4	5.11	85.17
46	30.0	2.48	41.33	96	63.2	3.34	55.67	146	99.2	5.35	89.17
47	30.6	2.50	41.67	97	63.8	3.35	55.83	147	99.4	5.44	90.67
48	31.4	2.52	42.00	98	64.4	3.37	56.17	148	99.6	5.55	92.50
49	32.2	2.54	43.33	99	65.2	3.39	56.50	149	99.6	5.55	92.50
50	32.6	2.55	45.50	100	66.00	3.41	56.83	150	99.8	5.71	95.17

TABLE XIX

PERCENTILE SCORES ASSIGNED TO EACH TEST-ITEM WHICH CORRESPOND TO VARIOUS PERCENTAGES OF PUPILS WHO FAIL TO SOLVE ITEMS, BASED UPON AREA OF PROBABILITY CURVE ASSUMING THE BASE LINE TO BE BROKEN OFF AT $\pm 3\sigma$. (TEST 1, PART II—PLANT BIOLOGY)

Item Number	Per Cent Failing	Distance x/σ	Percentile Score	Item Number	Per Cent Failing	Distance x/σ	Percentile Score	Item Number	Per Cent Failing	Distance x/σ	Percentile Score
1	.2	.29	4.83	34	31.6	2.53	42.17	67	64.6	3.37	56.17
2	.6	.57	9.17	35	32.8	2.56	42.67	68	65.8	3.40	56.67
3	1.0	.72	12.00	36	33.8	2.59	43.17	69	66.8	3.43	57.17
4	1.6	.89	14.83	37	34.6	2.61	43.50	70	67.6	3.45	57.50
5	1.8	.94	15.67	38	35.6	2.63	43.83	71	68.2	3.47	57.83
6	2.4	.98	16.33	39	36.6	2.66	44.33	72	69.0	3.50	58.33
7	2.8	1.11	18.50	40	37.4	2 68	44.67	73	69.6	3.51	58.67
8	3.6	1.22	20.33	41	38.4	2.71	45.17	74	70.6	3.54	59.00
9	4.6	1.33	22.17	42	39.2	2.73	45.50	75	71.8	3.57	59.50
10	5.6	1.42	23.67	43	40.8	2.77	46.17	76	73.6	3.63	60.50
11	6.6	1.51	25.17	44	42.4	2.81	46.83	77	74.2	3.65	60.83
12	7.4	1.56	26.00	45	43.4	2.84	47.33	78	75.6	3.69	65.50
13	8.6	1.64	27.33	46	44.4	2.86	47.67	79	76.8	3.73	62.17
14	9.6	1.70	28.33	47	45.8	2.90	48.33	80	77.8	3.79	63.17
15	10.4	1.75	29.17	48	46.8	2.92	48.67	81	78.8	3.80	63.33
16	10.8	1.77	29.50	49	47.8	2.95	49.17	82	79.8	3.83	63.83
17	11.4	1.80	30.00	50	48.6	2.97	49.33	83	81.2	3.88	64.67
18	12.4	1.85	30.83	51	49.2	2.98	49.67	84	82.4	3.94	64.67
19	14.8	1.93	32.17	52	49.8	2.99	49.83	85	83.8	3.98	66.33
20	15.8	2.00	33.33	53	50.6	3.01	50.17	86	84.8	4.02	67.00
21	16.6	2.04	34.00	54	51.2	3.03	50.50	87	86.2	4.08	68.00
22	17.6	2.08	34.67	55	51.8	3.04	50.67	88	87.4	4.14	69.00
23	18.8	2.12	35.33	56	52.6	3.06	51.00	89	88.6	4.20	70.00
24	19.4	2.14	35.67	57	53.8	3.09	51.50	90	89.8	4.26	71.00
25	20.8	2.19	36.50	58	54.6	3.11	51.87	91	90.6	4.31	71.83
26	21.8	2.23	37.17	59	54.8	3.12	52.00	92	91.8	4.38	72.00
27	23.4	2.28	38.00	60	56.4	3.16	52.67	93	92.8	4.45	74.17
28	24.4	2.31	38.50	61	57.4	3.19	53.17	94	94.0	4.55	75.83
29	24.8	2.32	38.67	62	58.2	3.21	53.50	95	95.0	4.64	77.33
30	26.6	2.37	39.67	63	59.2	3.23	53.83	96	96.2	4.76	79.33
31	27.8	2.42	40.33	64	60.4	3.26	54.33	97	97.4	4.92	82.00
32	29.4	2.46	41.00	65	62.2	3.31	55.17	98	98.2	5.06	84.33
33	30.4	2.49	41.67	66	63.4	3.34	55.67	99	99.2	5.35	89.17
								100	99.6	5.59	93.17

TEST 1

PLANT BIOLOGY

Form A

Part I—Simple recall..... 60 items
Part II—Multiple response..... 40 items

Form B

Part I—Simple recall..... 60 items
Part II—Multiple response..... 40 items

TEST 2

ANIMAL AND HUMAN BIOLOGY

Form A

Part I—Simple recall..... 60 items
Part II—Multiple response..... 40 items

Form B

Part I—Simple recall..... 60 items
Part II—Multiple response..... 40 items

In selecting the items for the various forms of the final tests, the next step is to find the percentage of measures to be assigned to each of the ten groups shown in Figure 1. In the case of Part 1 of each test, 120 items have to be distributed, that is, 60 items in Form A and 60 in Form B. It has been previously found that the percentages of the entire area between 0 and .6σ, between .6σ and 1.2σ, between 1.2σ and 1.8σ, between 1.8σ and 2.4σ, and between 2.4σ and 3σ are, respectively, .135, 3.77, 7.92, 15.92, and 22.57. Multiplying these percentages by 120, the number of test-items in Part I, there is obtained the number of items needed for the divisions: .8, 3.3, 9.5, 19.1, and 27.1, respectively. The number of items needed for the divisions beyond 3σ are of course the same in descending order, 27.1, 19.1, 9.5, 3.3. and .8. It is impossible to have fractional numbers of items, so the distribution is as follows: 1–3–10–19–27–27–19 10–3–1.

Part 2 of each test contains 80 items, that is, 40 items in

Form A and 40 in Form B, and by the same method of procedure the number of items to be included in the ten divisions are:
1–2–6–13–18–18–13–6–2–1.

Table XVIII shows the percentile rank of the various simple recall type of test-items from the point of view of the difficulty of the items. Since this type of item is that used in Part I of each form of Test 1 and Test 2, to secure items of equivalent difficulty, it is simply necessary to select items of equal or approximately equal percentile scores. For example, in Test 1, Form A, 60 items are needed and Test 1, Form B, 60 items. There are 150 possible items of the simple recall type from which 120 for the two forms must be selected. The problem is to discard 30 items leaving 120 paired as equally as possible. These items are selected on the basis of percentile scores. There will be little difference between the percentile scores in the middle of the distribution, a slightly larger difference occurs between those at the ends. At the easy end of the distribution, the first seven items (Table XVIII) have percentile scores ranging from 7.5 to 18.5, inclusive. From this group of seven items four are to be selected. Since all are comparatively easy items, numbers 2 and 7 are selected for Test 1, Form A, and numbers 3 and 4 are selected for Test 1, Form B, on the basis of the criteria determined by the nature of the content of the tests and in light of the standards set up in Chapters II and III. In other words, test-items were selected when possible to do so, to fall under various major topics of biology in proportionate degree to the stress they received in all the sources of this investigation. In similar manner the 60 items necessary for each form of Test 1 are selected. The procedure is the same for Part II of Test 1, Forms A and B, also for the various parts and the two forms of Test 2. The number of test-items selected from the various topics of biology which are used in the final tests is shown in Table XX.

TABLE XX

DISTRIBUTION OF TEST-ITEMS FOR THE VARIOUS TOPICS OF BIOLOGY USED IN THE FINAL TESTS

TEST I

Plant Biology

TITLE	FORM A		FORM B		TOTAL
	PART I	PART II	PART I	PART II	
Cells	3	1	4	2	10
Seeds	6	5	5	5	21
Roots	3	2	3	1	9
Stems	4	3	3	4	14
Forestry	2	2	1	1	6
Leaves	4	2	3	3	12
Plant physiology	5	4	6	4	19
Flowers	6	3	5	3	17
Fruits	2	2	3	2	9
Plant breeding	1	..	1	1	3
Bacteria	2	2	2	2	8
Lower forms	1	1	5	..	7
Soil	2	2	2	..	6
Economics of plants	3	2	3	1	9
Classification of plants	2	1	..	1	4
Symbiosis	1	1	1	1	4
Conservation of plants	1	1	1	..	3
Foods	4	2	4	2	12
Stimulants, narcotics and drugs	2	1	2	1	6
Introductory material	4	2	4	3	13
Heredity and evolution	1	1	1	1	4
Biography	1	..	1	2	4
Total	60	40	60	40	200

TABLE XX—*Continued*

TEST 2

Animal and Human Biology

	FORM A		FORM B		
	PART I	PART II	PART I	PART II	TOTAL
Insects	8	7	10	7	32
Crustaceans	2	1	2	2	7
Worms	1	1	2	1	5
Molluscs	1	1	..	..	2
Protozoa	3	1	2	1	7
Simple metazoa	1	1	1	1	4
Amphibians	2	3	3	..	8
Fishes	3	1	2	1	7
Reptiles	..	1	..	2	3
Birds	3	2	1	1	7
Mammals	2	..	1	2	5
Classification of animals	2	1	1	2	6
Animal breeding	..	..	1	..	1
Life Processes	3	2	4	4	13
Economics of invertebrates	3	1	2	3	9
Economics of vertebrates	1	1	1	1	4
Bacteria	1	..	1	..	2
Cells	1	..	1	..	2
Structure (H. B.)	3	2	2	2	9
Foods	2	1	1	..	4
Digestion (H. B.)	2	1	3	2	8
Respiration (H. B.)	2	..	2	..	4
Circulation (H. B.)	3	3	4	..	10
Nervous system (H. B.)	3	2	4	2	11
Excretion (H. B.)	1	..	2	..	3
Stimulants, narcotics and drugs (H. B.)	..	1	..	..	1
Health (H. B.)	4	4	5	3	16
Heredity and evolution	1	1	2	2	6
Biography	2	1	..	1	4
Total	60	40	60	40	200

The Nature of the Tests

In order that the reader may get a clear impression as to the nature of the tests, they are here reproduced in full. An examination of the tests shows them to be composed of two sets: one for plant biology with equivalent Forms A and B, and one for animal and human biology with equivalent Forms A and B. Test 1, Forms A and B, is designed for those pupils who have studied plant biology for one semester or four and one-half

months. Test 2, Forms A and B, is designed for those pupils who have studied animal and human biology for one semester or four and one-half months. Forms A and B of either test are identical in construction, and the items of Test 1 or Test 2 for each form are of approximately equal difficulty.

TEST 1: PLANT BIOLOGY—FORM A

For Secondary Schools

Do not open this paper, or turn it over, until you are told to do so. Fill these blanks, giving your name, age, birthday, etc. Write plainly.

Name.....
(First name, initial, and last name)

Age last birthday.....years. Birthday.....
(Month and day only)

Grade or class.....Teacher.....
School.....City.....
Date of examination.....Months of instruction in biology.....

This test is in two parts. The directions for each part are printed at the beginning of the part. Read the directions carefully and proceed to answer the questions. There is a time limit for each part. You are not expected to answer all the questions in either part before the time is up; but if you should, go back and make sure your answers are right. Do not begin Part II until you are told to. If you have not finished Part I when the time is up, stop work on it and go on to Part II at once. Ask no questions after the examination has begun.

PART	SCORE
I	
II	
Total	

PART I

DIRECTIONS. On each of the blanks at the right, put the one **word or short phrase** that makes the truest answer, as shown in the sample. Write carefully and clearly.

SAMPLE.

a. The science that treats of living plants and animals is called..... (**biology**)

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1. The unit of plant tissue is the..... (_____) 1
2. The substance formed by the union of two or more elements is called a..... (_____) 2
3. The color of the calyx of a flower is usually..... (_____) 3
4. Drying substances causes a decrease in their weight. This loss of weight is due chiefly to the loss of..... (_____) 4
5. Seeds that have two cotyledons are called..... (_____) 5
6. The best solution to use in testing for starch is..... (_____) 6
7. The principal absorptive agents of roots of plants are... (_____) 7
8. The flat portion of the leaf, in which veins are found, is called the..... (_____) 8
9. In corn grains the largest amount of starch is stored in the (_____) 9
10. A group of similar cells doing a similar work is called a (an) (_____) 10
11. Liquids and solids in solution pass through membranes. This process is called..... (_____) 11
12. Energy from the sun is received and used by plants principally through their..... (_____) 12
13. The element constituting about 80% of the air is..... (_____) 13
14. The waste product of respiration of plants is..... (_____) 14
15. The plant from which calico is prepared is named..... (_____) 15
16. Stamens are organs of a plant which produce..... (_____) 16
17. That portion of the embryo of a seed which develops into the stem is the..... (_____) 17
18. The age of trees may be determined by their..... (_____) 18
19. The transfer of pollen from anthers to stigmas in flowers is known as..... (_____) 19
20. A raw material other than water necessary for starch making is..... (_____) 20
21. The floral envelope of a flower is composed of the corolla and the..... (_____) 21
22. Ovules of plants develop into..... (_____) 22
23. Desert regions may be made favorable for plant growth by means of..... (_____) 23

24. Botanically, the ripened ovary with its contents of a flower is called a (an)..... (_____) 24
25. The chemical union of oxygen with any other substance is called..... (_____) 25
26. The scar left on the testa where the seed was attached to the pod is the..... (_____) 26
27. Linseed oil is prepared from..... (_____) 27
28. That portion of the embryo which develops into the root is the..... (_____) 28
29. Plants that grow two years but do not produce seeds the first year are known as..... (_____) 29
30. Protoplasm-building foods are named..... (_____) 30
31. The best and purest granulated sugar is prepared from.. (_____) 31
32. An element added to the soil from the air by means of leguminous plants is called..... (_____) 32
33. The principal by-product resulting from food making in the leaves of plants is..... (_____) 33
34. The balanced aquarium illustrates the principle of..... (_____) 34
35. Plants give off large quantities of water through their leaves. This process is known as..... (_____) 35
36. An embryo plant provided with food and protected by coatings is called a..... (_____) 36
37. Stems, such as the cactus, that have undergone some change to meet better their surrounding conditions are said to be..... (_____) 37
38. The name of the man who developed the spineless cactus and seedless orange is..... (_____) 38
39. The region of active growth in woody stems is the..... (_____) 39
40. Corn is pollinated chiefly by the agency of..... (_____) 40
41. A plant that is dependent upon another for its existence is named a..... (_____) 41
42. The point on a stem at which a leaf is attached is called a (_____) 42
43. The greatest enemy of forests in the United States is.... (_____) 43
44. The calyx of a flower is composed of..... (_____) 44
45. The type of veining found in the leaves of all grasses is named..... (_____) 45
46. The small opening on the ovule through which the pollen tube enters is named the..... (_____) 46
47. Fleshy fruits like the pear and apple are called..... (_____) 47
48. The substance most used by man for fuel is..... (_____) 48
49. Flowers which have both stamens and pistils are said to be (_____) 49

50. The process that does not destroy the nutritive qualities of milk but that does destroy disease germs is named. (_____) 50
51. The green coloring matter in the leaves of plants is named (_____) 51
52. A liquid obtained from fermentation and distillation of fruits and grains is (_____) 52
53. One of the best natural fertilizers is (_____) 53
54. The root hairs of young roots are outgrowths from the (_____) 54
55. There are two arrangements of leaves on stems: one is **opposite**; the other is (_____) 55
56. Flowerless plants reproduce by simple cells named (_____) 56
57. Stipules are small appendages found on some stems connected with the (_____) 57
58. A flower that is composed of both ray and disk flowers is said to be (_____) 58
59. The stem-like part of the pistil above the ovary is the (_____) 59
60. The folding of leaves in the bud is named (_____) 60

Number right..... (Score, Part I)

PART II

DIRECTIONS. Each of the following sentences is followed by five alternative answers, of which only **one** is correct. Select the one that is correct and put its number in the parentheses at the right, as shown in the sample.

SAMPLE.

a. Buds are protected during the winter by—
1 bark 2 rings of growth 3 bud scales 4 epidermis 5 sapwood (3)

---

1. An example of a polycotyledon is the—
1 pine 2 daisy 3 mahogany 4 lima bean 5 date ( ) 1
2. The symbol for carbon dioxide is—
1 HCl 2 H_2O 3 CO 4 CO_2 5 NaCl ( ) 2
3. The largest structure on the lima bean is the—
1 plumule 2 micropyle 3 cotyledon 4 hilum 5 embryo ( ) 3
4. Plants take in water through their roots by means of—
1 osmosis 2 turgescence 3 solution 4 capillarity 5 suction ( ) 4
5. Leaves are used primarily by plants for—
1 shade 2 ornamentation 3 food making 4 green color 5 holding water ( ) 5

6. An undeveloped plant is known as the—
1 cotyledon 2 hilum 3 embryo 4 testa 5 micropyle.( ) 6
7. Linen is obtained from—
1 jute 2 hemp 3 yucca 4 cotton 5 flax.....( ) 7
8. The use of oxygen and the giving off of carbon dioxide by protoplasm is called—
1 absorption 2 respiration 3 circulation 4 assimilation 5 diffusion.....( ) 8
9. Plants are developed primarily by means of—
1 seeds 2 roots 3 grafting 4 cuttings 5 transplanting.( ) 9
10. Lenticles aid in—
1 seed dispersal 2 pollination 3 assimilation 4 respiration 5 digestion.....( ) 10
11. The process of the manufacture of food in the leaves of plants is—
1 photosynthesis 2 transpiration 3 osmosis 4 geotropism 5 heliotropism.....( ) 11
12. The sepals and petals of a flower taken collectively compose the—
1 calyx 2 essential organs 3 corolla 4 receptacle 5 perianth.....( ) 12
13. A good example of a leguminous plant is the—
1 fern 2 corn 3 alfalfa 4 aster 5 orange....( ) 13
14. A seed that is well adapted for seed dispersal by animals is the—
1 plantain 2 jimson weed 3 jewelweed 4 touch-me-not 5 cocklebur.....( ) 14
15. A plant that has aerial roots is the—
1 dahlia 2 parsnip 3 mistletoe 4 English ivy 5 pumpkin ( ) 15
16. An example of a modified stem that is very useful to man is the—
1 flax 2 onion 3 jute 4 yucca 5 rye.....( ) 16
17. Materials for tanning leather are obtained principally from—
1 pines 2 oaks 3 poplars 4 maples 5 firs...( ) 17
18. A good example of an organic substance is—
1 water 2 gold 3 gas 4 wood 5 glass.....( ) 18
19. All of the sepals of a flower taken collectively are called the—
1 convolucre 2 corolla 3 pistil 4 calyx 5 stamen..( ) 19
20. The drug found in coffee that produces a stimulating effect on the nervous system is called—
1 opium 2 caffeine 3 tannin 4 aspirin 5 ipecac..( ) 20
21. Apple trees are sprayed in the spring of the year to—
1 keep away birds 2 kill insect pests 3 loosen bud scales 4 cause early blooming 5 slow the growth of fruit..( ) 21

22. A good example of a plant having modified leaves is the—
1 pitcher plant 2 elm 3 clematis 4 poplar 5 elephant ears.....( ) 22

23. The development of embryos from fertilized eggs is termed—
1 reproduction 2 mitosis 3 hermaphroditism 4 symbiosis 5 parthenogenesis.....( ) 23

24. The best wood for airship propellers is
1 white pine 2 mahogany 3 oak 4 cypress 5 gum..( ) 24

25. All leaves are veined. The leaves of horse chestnut trees are a type of venation known as—
1 parallel 2 compound palmate 3 pinnate 4 palmate 5 compound pinnate.....( ) 25

26. A large quantity of paper is made from the pulp of—
1 oaks 2 poplars 3 walnuts 4 bones 5 cornstalks..( ) 26

27. A dry indehiscent fruit, such as produced by the dandelion, is called a—
1 legume 2 grain 3 nut 4 drupe 5 akene....( ) 27

28. A good example of a leafless plant is the—
1 snowball 2 hops 3 morning glory 4 aster 5 dodder..( ) 28

29. A tree that bears cones in which seeds are produced is the—
1 oak 2 date 3 pine 4 maple 5 willow.....( ) 29

30. A soil that contains much humus is called—
1 silt 2 sand 3 loam 4 clay 5 subsoil.....( ) 30

31. The vexillum is a specialized petal found on the flowers of—
1 nasturtiums 2 geraniums 3 sunflowers 4 sweet peas 5 hyacinths.....( ) 31

32. Fungi reproduce by means of—
1 leaves 2 roots 3 seeds 4 stems 5 spores..( ) 32

33. The arrangement of veins in leaves is called—
1 venation 2 inflorescence 3 vernation 4 heliotropism 5 bract.....( ) 33

34. A plant that develops a rhizome is the—
1 fern 2 crocus 3 sweet potato 4 asparagus 5 onion..( ) 34

35. A plant that furnishes a supply of food for the reindeer is the—
1 corn 2 bluegrass 3 lichen 4 alfalfa 5 red clover..( ) 35

36. The development of new organisms formed by the fertilization of one species of plants by another which are closely related is called—
1 fungi 2 parasites 3 hybrids 4 hydrophytes 5 saprophytes.....( ) 36

37. The scutellum is an organ found on seeds such as—
1 beans 2 peanuts 3 sweet peas 4 alfalfa 5 corn..( ) 37

38. Practically all binder twine is prepared from—
1 yucca 2 cotton 3 hemp 4 sisal 5 flax....( ) 38

39. Flowers that bear stamens only are said to be—
1 polypetalous 2 pistillate 3 asepalous 4 staminate 5 perfect.....( ) 39

40. The part of the ovary to which the young seeds are attached and through which they get their first food is called the—
1 style 2 receptacle 3 stigmas 4 filament 5 placenta..( ) 40

Number right.....(Score, Part II)

TEST 1: PLANT BIOLOGY—FORM B

For Secondary Schools

Do not open this paper, or turn it over, until you are told to do so. Fill these blanks, giving your name, age, birthday, etc. Write plainly.

Name.....
(First name, initial, and last name)

Age last birthday.....years. Birthday.....
(Month and day only)

Grade or Class.....Teacher.....

School.....City.....

Date of examination.....Months of instruction in biology.....

This test is in two parts. The directions for each part are printed at the beginning of the part. Read the directions carefully and proceed to answer the questions. There is a time limit for each part. You are not expected to answer all the questions in either part before the time is up. But if you should, go back and make sure your answers are right. Do not begin Part II until you are told to. If you have not finished Part I when the time is up, stop work on it and go on to Part II at once. Ask no questions after the examination has begun.

Part	Score
I	
II	
Total	

PART I

DIRECTIONS. On each of the blanks at the right, put the one **word** or **short phrase** that makes the truest answer, as shown in the sample. Write carefully and clearly.

SAMPLE.

a. The science that treats of living plants and animals is called..... (biology)

---

1. The testa is a covering found on..... (_____) 1
2. Peanut butter is prepared from..... (_____) 2
3. The living matter found in all living plants and animals is called..... (_____) 3
4. When iodine is used to test starch, the color obtained is. (_____) 4
5. The color of practically all leaves is..... (_____) 5
6. The essential organs of a flower are the stamens and the. (_____) 6
7. The hypocotyl of the embryo of a seed develops into the. (_____) 7
8. The food substance found in beans and peas in large quantities is..... (_____) 8
9. A mass of protoplasm containing a nucleus is called a... (_____) 9
10. Microscopic one-celled plants causing many specific diseases are named..... (_____) 10
11. A group of similar tissues performing a special work is called a (an)..... (_____) 11
12. The leaves of the pine tree are called..... (_____) 12
13. Breathing pores found in the epidermis of stems are called (_____) 13
14. The parts of the stamen are the filament and the..... (_____) 14
15. The cultivation of several different crops on the same soil during one year or alternate years is called..... (_____) 15
16. The arrangement of veins in the maple represents a type of venation called..... (_____) 16
17. One of the leaf-like parts of the corolla is named a (an).. (_____) 17
18. A plant of any kind growing in a place where it is not wanted or needed is called a (an)..... (_____) 18
19. Transpiration in plants takes place through their..... (_____) 19
20. The **group** of foods that plants make out of carbon dioxide and water is named..... (_____) 20
21. A condition in which two or more organisms of a different nature live together to their mutual advantage is called (_____) 21
22. Food materials and water are taken from the ground into a plant through the..... (_____) 22
23. The plant from which castor oil is obtained is the..... (_____) 23

24. Plants that complete their life history or cycle of growth in one year are called.....(_____) 24
25. A food substance which turns yellow when treated with nitric acid is called.....(_____) 25
26. Digestion of food first takes place in growing plants during the period of.....(_____) 26
27. The plant causing fermentation to be brought about in bread making is.....(_____) 27
28. The thread-like projection that develops when a pollen grain lodges on the stigma of the pistil is called a....(_____) 28
29. The dried juice of the poppy is the principal source of..(_____) 29
30. The stem-like organ which supports the blade of a leaf is the.....(_____) 30
31. Champagne is prepared from.....(_____) 31
32. Generally speaking, the organs of plants which contain chlorophyll are the.....(_____) 32
33. Vitamins have been proved valuable as a (an).....(_____) 33
34. A good example of a plant which reproduces by means of budding is.....(_____) 34
35. That portion of the pistil in which ovules develop is the.(_____) 35
36. The first man to work with flowers scientifically and to state the laws of heredity was.....(_____) 36
37. Plants throw off waste matter from their bodies. This process is called.....(_____) 37
38. The process of the manufacture of food in green plants is called.....(_____) 38
39. The substance necessary for fertilization of ovules is....(_____) 39
40. The greatest loss of water in plants takes place through the.....(_____) 40
41. A plant, such as the pine, which has three or more cotyledons is called a (an).....(_____) 41
42. That portion of the female reproductive organ in a flower which receives the pollen is called the.....(_____) 42
43. The act of inserting scions on to a stem is called.....(_____) 43
44. A green parasitic plant bearing berries, and that usually grows upon oak trees, is.....(_____) 44
45. The "tassel" of the cornstalk produces.....(_____) 45
46. A unicellular fungus that causes fermentation is named.(_____) 46
47. Mushrooms are unable to manufacture food as green plants do, because they lack.....(_____) 47
48. The delicate transparent covering of leaves is called the.(_____) 48

49. Another name for vegetable mold is.....(_____) 49
50. A tall, slender tree, such as the cypress, with one main stem only, is an example of a type of branching known as.....(_____) 50
51. A poisonous substance found in tobacco is.....(_____) 51
52. The kidney-shaped cells of a stoma are called.....(_____) 52
53. The effect of gravity on roots and stems is called.....(_____) 53
54. Flowers that have a pistil but no stamens are called....(_____) 54
55. The offspring developed by the crossing of two different species or varieties of plants is a.....(_____) 55
56. The substance which makes up the cell wall of practically all plants is called.....(_____) 56
57. Germicides are harmful to protozoa and to.....(_____) 57
58. The hard woody portion of a fibrovascular bundle is called.....(_____) 58
59. Sori are "fruit dots" found on the leaves of.....(_____) 59
60. Fruits that split open or explode to discharge their seeds are said to be.....(_____) 60

Number right.....(Score, Part I)

PART II

DIRECTIONS. Each of the following questions is followed by five alternative answers, of which only **one** is correct. Select the one that is correct and put its number in the parentheses at the right, as shown in the sample.

SAMPLE.

a. Buds are protected during the winter by—
1 bark 2 rings of growth 3 bud scales 4 epidermis 5 sapwood.....(3)

---

1. The presence of grape sugar in any substance may be detected by the use of—
1 iodine 2 sodium hydroxide 3 nitric acid 4 Fehling's solution 5 burning.....( ) 1
2. The principal agent responsible for the dispersal of seeds of the maple tree is—
1 man 2 birds 3 water 4 animals 5 wind..( ) 2
3. Another name for combustion is—
1 fusion 2 melting 3 freezing 4 oxidation 5 drying..( ) 3
4. A group of cells specialized for a definite work is called a—
1 pupa 2 organ 3 tissue 4 system 5 organism....( ) 4

5. A part of the embryo of a plant is the—
1 hilum 2 peduncle 3 hypocotyl 4 testa 5 micropyle. ( ) 5
6. A solution to use in testing for carbon dioxide is—
1 ammonia 2 limewater 3 lye 4 salt water 5 syrup.. ( ) 6
7. Carbohydrates are composed of—
1 oxygen 2 sugars and starches 3 fats and proteins 4 nitrogen 5 sugars and proteins.....( ) 7
8. Seeds are attached to the pod by means of a—
1 peduncle 2 hilum 3 epicotyl 4 micropyle 5 auricle. ( ) 8
9. The most successful breeder of plants the world has ever known was—
1 Burbank 2 Cuvier 3 Burroughs 4 Gray 5 Audubon. ( ) 9
10. The condition under which plants and animals live and grow is known as—
1 environment 2 reproduction 3 external structure 4 digestion 5 excretion.....( ) 10
11. An example of a composite flower is the—
1 geranium 2 daisy 3 sweet pea 4 snowball( )
5 violet.....( ) 11
12. The peach is a fleshy fruit which is classified as a—
1 berry 2 multiple 3 palm 4 drupe 5 akene....( ) 12
13. An example of a monocotyledon is—
1 wheat 2 mountain ash 3 oak tree 4 fern 5 cucumber.....( ) 13
14. Flowers are developed on plants for the purpose of—
1 ornamentation 2 perfume 3 seed production 4 stems 5 leaves.....( ) 14
15. Plants take oxygen into their bodies by means of—
1 transpiration 2 capillarity 3 respiration 4 adhesion 5 turgescence.....( ) 15
16. Young plants leave the seed, when they begin to grow, by way of the—
1 cotyledon 2 micropyle 3 testa 4 hilum 5 endosperm( ) 16
17. A good example of a citrus fruit is the—
1 lemon 2 quince 3 peach 4 cactus 5 prune....( ) 17
18. One of the most important chemical elements in the life of man is—
1 water 2 carbon dioxide 3 air 4 sugar 5 oxygen. ( ) 18
19. The white (Irish) potato is an underground stem extensively used for food and is known as a—
1 corm 2 stolon 3 bulb 4 runner 5 tuber.. ( ) 19

20. Peach trees that grow from seeds are made desirable for fruit bearing by—
1 pruning 2 budding 3 cutting 4 grafting 5 belting. ( ) 20

21. Plant cells take digested food and turn it into living matter. This process is called—
1 fertilization 2 secretion 3 assimilation 4 transpiration 5 absorption ..... ( ) 21

22. The part of the flower which produces the male cell or sperm is the—
1 ovary 2 anther 3 perianth 4 stigma 5 peduncle .. ( ) 22

23. Trees grow symmetrically by means of—
1 pruning 2 grafting 3 crop rotation 4 spraying 5 abundant rainfall ..... ( ) 23

24. The liberation of water from the leaves of plants is a process known as—
1 transpiration 2 respiration 3 oxidation 4 plasmolysis 5 transfusion ..... ( ) 24

25. The element found in the greatest abundance in the air is—
1 oxygen 2 nitrogen 3 carbon dioxide 4 calcium 5 hydrogen ..... ( ) 25

26. A by-product in both plants and animals as a result of respiration is—
1 hydrogen 2 urine 3 limewater 4 carbon dioxide 5 calcium carbonate ..... ( ) 26

27. A part of the pistil of a flower is the—
1 filament 2 pedicle 3 bract 4 ovary 5 anther .. ( ) 27

28. The man who gave to the world most of the principle of evolution was—
1 Burbank 2 Mendel 3 Pasteur 4 Hooke 5 Darwin . ( ) 28

29. The substance found in greatest quantity in grains of rye is—
1 protein 2 sugar 3 fat 4 carbon dioxide 5 starch .. ( ) 29

30. A plant of which the roots are used in the preparation of medicine is the—
1 poppy 2 red clover 3 rhubarb 4 milkweed 5 burdock ..... ( ) 30

31. The union of a sperm cell of a pollen grain with the ovule results in—
1 conjugation 2 osmosis 3 transpiration 4 fertilization 5 pollination ..... ( ) 31

32. Winesaps are a species of—
1 grapes 2 apples 3 currants 4 peaches 5 peanuts . ( ) 32

33. A layer of cells found under the top epidermis on the blade of a leaf is the—
1 spongy parenchyma 2 air space 3 vascular bundle 4 stomata 5 palisade.....( ) 33

34. The grain or flaky appearance in quarter-sawed oak is produced by—
1 heartwood 2 medullary rays 3 annual rings 4 sapwood 5 fibrovascular bundles.....( ) 34

35. An example of a plant that does not contain chlorophyll is the—
1 duckweed 2 mistletoe 3 mushroom 4 English ivy 5 arbutus.....( ) 35

36. The protein found in wheat is—
1 gluten 2 legumin 3 casein 4 peptone 5 albumen.( ) 36

37. The modern method of plant classification and naming was first devised by—
1 Linnaeus 2 Galton 3 Hooke 4 Huxley 5 Agassiz.( ) 37

38. The outer part of a vascular bundle is called—
1 phylum 2 xylem 3 epidermis 4 phloem 5 cortex.( ) 38

39. A typical example of an indehiscent fruit is the—
1 lima bean 2 jimson weed 3 chestnut 4 violet 5 corn.....( ) 39

40. The middle portion of a leaf, composed of loosely packed cells, is the—
1 stomata 2 lower epidermis 3 palisade cells 4 vascular bundle 5 mesophyll.....( ) 40

Number right.....(Score, Part II)

TEST 2: ANIMAL BIOLOGY—FORM A

For Secondary Schools

Do not open this paper, or turn it over, until you are told to do so. Fill these blanks, giving your name, age, birthday, etc. Write plainly.

Name.....
(First name, initial, and last name)

Age last birthday.....years Birthday.....
(Month and day only)

Grade or class.....Teacher.....

School.....City.....

Date of examination.....Months of instruction in biology.....

This test is in two parts. The directions for each part are printed at the beginning of the part. Read the directions carefully and proceed to answer the questions. There is a time limit for each part. You are not expected to answer all the questions in either part before the time is up; but if you should, go back and make sure your answers are right. Do not begin Part II until you are told to. If you have not finished Part I when the time is up, stop work on it and go on to Part II at once. Ask no questions after the examination has begun.

Part	Score
I	
II	
Total	

PART I

DIRECTIONS. On each of the blanks at the right, put the one **word** or **short phrase** that makes the truest answer, as shown in the sample. Write carefully and clearly.

SAMPLE.

a. The science that treats of living plants and animals is called..... (**biology**)

---

1. The principal use of the antennæ of insects is..... (_____) 1
2. An odorless gas given off as a result of respiration in animals is..... (_____) 2
3. Birds are distinguished from other animals chiefly by means of their..... (_____) 3
4. Undeveloped female honey bees of the hive are named. (_____) 4
5. The organs of locomotion and balance of fishes are the.. (_____) 5
6. Respiration is a process necessary for animal and plant life. Of all the elements taken in through respiration, the most important is..... (_____) 6
7. An example of an insect having scale wings is the..... (_____) 7
8. A collection or group of organs concerned with the same general work is named a (an)..... (_____) 8
9. The sweet substance which bees collect from flowers is named..... (_____) 9
10. An insect equipped with a pollen basket is the..... (_____) 10
11. The number of pairs of wings found on the grasshopper is(_____) 11
12. A food substance found in great abundance in lean meat, eggs, and cheese is..... (_____) 12
13. Vessels that convey blood from the heart are named.... (_____) 13
14. The chief enemies of insects are..... (_____) 14
15. The first man to study bacteria scientifically was..... (_____) 15
16. The layer of skin below the epidermis is the..... (_____) 16
17. Chitin is a firm substance which composes the framework of the bodies of..... (_____) 17
18. The bodies of most fishes are covered with..... (_____) 18
19. The living material of which all living organisms are composed is named..... (_____) 19
20. The name given to the yellowish fat that fills hollow bones is..... (_____) 20
21. The type of eye found on the crayfish is named..... (_____) 21
22. The stage of life of an insect following the larval stage is the..... (_____) 22

23. The heart of the human being has four cavities: two **ventricles** and two..... (_____) 23
24. The principal food found in the potato is named..... (_____) 24
25. A tadpole is the larval stage of the..... (_____) 25
26. Small one-celled plants that cause animal diseases are named..... (_____) 26
27. The organs used principally by the frog in swimming are the..... (_____) 27
28. Animals that possess a chain of bones in which a nerve cord is located are named..... (_____) 28
29. Tadpoles breathe by means of..... (_____) 29
30. The name of the man who discovered the circulation of the blood is..... (_____) 30
31. A one-celled animal most frequently found in hay infusion is the..... (_____) 31
32. Consumption is a disease known as tuberculosis of the.. (_____) 32
33. Respiration in the earthworm takes place through the... (_____) 33
34. The smallest blood vessels in the human body are the.. (_____) 34
35. An example of an annelid that is very beneficial to agriculture is the..... (_____) 35
36. Birds of prey are equipped with long, sharp claws called. (_____) 36
37. Bodies of higher animals are cooled by means of..... (_____) 37
38. The short, hair-like locomotive organs of the earthworm are named..... (_____) 38
39. Diseases may be spread by water used for drinking purposes due to the presence of..... (_____) 39
40. The eyes of man are connected with the brain by means of the..... (_____) 40
41. One-celled animals are generally known as..... (_____) 41
42. The protective bony case enclosing the brain is the..... (_____) 42
43. The most serious insect pest of the cotton plant of the United States is the..... (_____) 43
44. The number of toes found on the feet of practically all birds is..... (_____) 44
45. The most common rodent is the..... (_____) 45
46. The cells of which the blood is composed are named.... (_____) 46
47. The first man to study animals and to write about them to any extent was..... (_____) 47
48. The most numerous of all insects are the..... (_____) 48
49. The colored portion of the eye, containing the pupil, is the (_____) 49
50. The most valuable of all animal fibers is..... (_____) 50
51. The starfish moves from place to place by means of..... (_____) 51

52. The largest and heaviest of the rodents is the.....(_____) 52
53. A characteristic, such as color of eyes, that is transmitted from parent to offspring is called.....(_____) 53
54. A person who is not susceptible to a disease is said to be.(_____) 54
55. Animals of a given region of a given period of time are known as.....(_____) 55
56. Many one-celled animals move from place to place by means of numerous delicate threads of protoplasm extending from their bodies called.....(_____) 56
57. The insect primarily responsible for the pollination of red clover is the.....(_____) 57
58. The clam belongs to the branch or phylum named.....(_____) 58
59. Excretory organs of the crayfish which are located near the base of the antennules are named.....(_____) 59
60. The operculum of a fish is located on the.....(_____) 60

Number right.....(Score, Part I)

PART II

DIRECTIONS. Each of the following questions is followed by five alternative answers, of which only **one** is correct. Select the one that is correct and put its number in the parentheses at the right, as shown in the sample.

SAMPLE.

a. An animal useful to man is the—
1 San Jose scale 2 Hessian fly 3 tent caterpillar 4 tussock moth 5 ladybird beetle.....(**5**)

---

1. The most harmful stage in the development of the butterfly is the—
1 pupa 2 cocoon 3 larva 4 adult 5 egg....( ) 1
2. A famous American naturalist was—
1 Lister 2 Howard 3 Jordan 4 Audubon 5 Koch..( ) 2
3. The normal pulse rate is about—
1 58 2 70 3 84 4 110 5 62.....( ) 3
4. The beak of a bird is used chiefly for—
1 chewing food 2 singing 3 ornamentation 4 protection 5 picking up food.....( ) 4
5. A good example of a vertebrate is the—
1 spider 2 earthworm 3 toad 4 crayfish 5 caterpillar.( ) 5
6. Tracheæ are organs used for—
1 feeling 2 tasting 3 hearing 4 breathing 5 locomotion( ) 6

7. The eggs of the house fly are deposited in—
1 filth 2 clay 3 wood 4 webs 5 water.....( ) 7
8. The muscular chamber in birds where the food is ground is called—
1 crop 2 stomach 3 pancreas 4 intestine 5 gizzard..( ) 8
9. The number of distinct regions on the body of the crayfish is—
1 7 2 2 3 4 4 3 5 5.....( ) 9
10. An animal that breathes by means of gills is the—
1 lizard 2 turtle 3 tadpole 4 starfish 5 hydra ( ) 10
11. Locomotion of the snail is accomplished by means of—
1 crawling 2 walking 3 flying 4 swimming 5 jumping.( ) 11
12. An animal that has chelipeds is the—
1 lobster 2 frog 3 dragon fly 4 starfish 5 cockroach.( ) 12
13. The immature form of an insect, as the grasshopper, in which the development is an incomplete metamorphosis is called—
1 pupa 2 maggot 3 imago 4 larva 5 nymph....( ) 13
14. A communicable disease that may be contracted from drinking milk is—
1 pneumonia 2 malaria 3 diphtheria 4 smallpox 5 tuberculosis.....( ) 14
15. The "Origin of Species" was written by—
1 Mendel 2 Huxley 3 Darwin 4 Locy 5 Spencer..( ) 15
16. The stegomyia or Aëdes mosquito is known to spread germs that cause—
1 typhoid 2 yellow fever 3 bubonic plague 4 malaria 5 diphtheria.....( ) 16
17. An example of a bivalve is the—
1 oyster 2 snail 3 slug 4 starfish 5 lobster....( ) 17
18. Antennæ are organs used for—
1 seeing 2 feeling 3 hearing 4 breathing 5 swimming( ) 18
19. Mammals are distinguished by the possession of—
1 a circulatory system 2 one pair of eyes 3 milk glands 4 a nervous system 5 simple eyes.....( ) 19
20. A bird that is very useful to man is the—
1 robin 2 condor 3 crow 4 owl 5 hawk.....( ) 20
21. The large bone in the upper arm of man is the—
1 ulna 2 femur 3 radius 4 tibia 5 humerus....( ) 21
22. Animals possessing gill rakers are—
1 clams 2 grasshoppers 3 frogs 4 fishes 5 crayfishes.( ) 22
23. The largest gland of the human body, in which glycogen is stored, is the—
1 stomach 2 liver 3 kidney 4 pancreas 5 lung..( ) 23

24. Trichinæ are found in—
1 bread 2 butter 3 raw pork 4 apples 5 milk....( ) 24
25. The most deadly poisonous snake in the world is the—
1 rattler 2 moccasin 3 cobra 4 boa constrictor 5 python.....( ) 25
26. Chelæ are parts of—
1 fins 2 legs 3 wings 4 antennae 5 swimmerets..( ) 26
27. The strongest natural defense of the human body against disease germs is the work of the—
1 brain 2 muscles 3 lungs 4 white corpuscles 5 liver.....( ) 27
28. An elongated and coiled tubular appendage for gathering food, as in honey bees, is called a—
1 proboscis 2 labrum 3 palp 4 maxilla 5 mandible..( ) 28
29. Malaria is a disease caused by—
1 foul air 2 a protozoan 3 polluted drinking water 4 a bacterium 5 shaking hands.....( ) 29
30. Amphibians are animals that have the habit of spending their adult life partly on land and partly in the water. An example of this group is the—
1 frog 2 crocodile 3 lizard 4 turtle 5 lobster....( ) 30
31. The membrane covering the gills of fishes is called—
1 carapace 2 pleura 3 telson 4 operculum 5 thorax.( ) 31
32. Biting and gnawing mammals may be defined as—
1 ruminants 2 insects 3 annelids 4 snails 5 rodents.( ) 32
33. The large vein that carries blood to the liver is the—
1 portal 2 jugular 3 vena cava 4 pulmonary 5 radial.( ) 33
34. A dog is able to eat and digest bones because of a strong solution in its alimentary canal known as—
1 saliva 2 plasma 3 gastric juice 4 bile 5 pancreatic juice.....( ) 34
35. The amœba moves by means of—
1 fins 2 legs 3 villi 4 pseudopodia 5 flagella....( ) 35
36. A natural enemy of the mosquito is—
1 snake 2 honey bee 3 Japanese beetle 4 dragon fly 5 mole.....( ) 36
37. Mandibles are organs of insects found on the—
1 legs 2 thorax 3 wings 4 abdomen 5 head....( ) 37
38. Spiders are examples of—
1 insects 2 arachnids 3 crustaceans 4 cestoids 5 amphibians.....( ) 38

39. The absorptive action of the intestines of the earthworm is increased by means of the—

1 colon 2 fundus 3 typhlosole 4 spleen 5 villi....( ) 39

40. The principal drug used in the treatment of malaria is—

1 aspirin 2 calomel 3 opium 4 quinine 5 Epsom salts.( ) 40

Number right.....(Score, Part II)

TEST 2: ANIMAL BIOLOGY—FORM B

For Secondary Schools

Do not open this paper, or turn it over, until you are told to do so. Fill these blanks, giving your name, age, birthday, etc. Write plainly.

Name.....
(First name, initial, and last name)

Age last birthday.....years. Birthday.....
(Month and day only)

Grade or Class.....Teacher.....

School.....City.....

Date of examination.....Months of instruction in biology.....

This test is in two parts. The directions for each part are printed at the beginning of the part. Read the directions carefully and proceed to answer the questions. There is a time limit for each part. You are not expected to answer all the questions in either part before the time is up. But if you should, go back and make sure your answers are right. Do not begin Part II until you are told to. If you have not finished Part I when the time is up, stop work on it and go on to Part II at once. Ask no questions after the examination has begun.

Part	Score
I	
II	
Total	

PART I

DIRECTIONS. On each of the blanks at the right, put the one **word** or **short phrase** that makes the truest answer, as shown in the sample. Write carefully and clearly.

SAMPLE.

a. The science that treats of living plants and animals is called..... (**biology**)

---

1. The unit of all animal structure is the..... (_____) 1
2. The number of antennæ generally found on the bodies of insects is..... (_____) 2
3. The pupal stage of a butterfly is called a..... (_____) 3
4. The backbone or spine of a dog is composed of individual bones named..... (_____) 4
5. The one disease responsible for the greatest number of deaths in the world is..... (_____) 5
6. The openings on the side of an insect's abdomen which admit air to the body are named..... (_____) 6
7. The harmless mosquito is named the..... (_____) 7
8. The body of the earthworm is made up of a large number of rings or divisions named..... (_____) 8
9. The outer cellular layer of the skin is named the..... (_____) 9
10. Crayfishes breathe by means of..... (_____) 10
11. The change that an animal, such as the housefly, undergoes during its development is called a (an)..... (_____) 11
12. The grasshopper belongs to the branch or phylum named (_____) 12
13. An animal equipped with a clitellum is the..... (_____) 13
14. Foods which are useful to the body for muscle building are classified as..... (_____) 14
15. The eggs of toads are deposited in..... (_____) 15
16. The common name for the larval stage of the mosquito is (_____) 16
17. School children who are susceptible to diphtheria should be inoculated with..... (_____) 17
18. The housefly spreads the germs that cause..... (_____) 18
19. During the winter months, respiration in the frog takes place through the..... (_____) 19
20. The metamorphosis of the grasshopper is said to be.... (_____) 20
21. Blood is conveyed from the organs of the body to the heart by..... (_____) 21
22. The science that treats of the functions of the organs of the human body is named..... (_____) 22

23. An insect that maintains the highest type of social and communal organization is the.....(_____) 23
24. The outer portion of the crown of a tooth is composed of a hard layer of tissue named.....(_____) 24
25. The part of the body of the grasshopper on which the eardrums are located is the.....(_____) 25
26. Oxygen is carried in the blood by.....(_____) 26
27. Insects are provided with eyes composed of many small facets. This type of eye is named.....(_____) 27
28. A large number of honey bees, with a queen, migrating from a hive to start a new colony, is named a (an)...(_____) 28
29. The female crayfish deposits her eggs on.....(_____) 29
30. Generally, the flight of butterflies takes place during the.(_____) 30
31. The trunk of man is divided into two main divisions by means of the.....(_____) 31
32. Pseudopodia (false feet) are made use of for locomotion chiefly by the.....(_____) 32
33. The hard, horny substance forming the skeleton of insects and many other animal parts is named.....(_____) 33
34. The largest gland in the body is the.....(_____) 34
35. The organ on the head used by the adult butterfly to obtain food is the.....(_____) 35
36. The elimination of waste products of metabolism in the bodies of animals is named.....(_____) 36
37. Animals that obtain practically all of their nourishment from other living animals are named.....(_____) 37
38. The fluid of the blood in which corpuscles float is the...(_____) 38
39. The organ of which the ocellus is a type is the.....(_____) 39
40. The characteristic skeleton of invertebrates is.....(_____) 40
41. Animals composed of many cells are known as.....(_____) 41
42. That part of the eye which has the end organs of sight and receive stimuli from outside is the.....(_____) 42
43. Reproductive cells produced by the male of animals are named.....(_____) 43
44. Reproduction of protozoa takes place by means of.....(_____) 44
45. Bands of connective tissue which bind one bone to another are named.....(_____) 45
46. An animal using tube feet for locomotion is the.....(_____) 46
47. Bacteria give off poisonous substances named.....(_____) 47
48. Fleshy growths occurring in the back of the nasal cavity of human beings and having a tendency to block the air passages are named.....(_____) 48

49. The only order of insects having two wings is the.....(_____) 49
50. The disease which man has been very successful in combating by means of vaccination is.....(_____) 50
51. Caviar is prepared from the eggs of the.....(_____) 51
52. A group or a mass of nerve cells is called a.....(_____) 52
53. Small sucking insects such as plant lice of garden shrubs are named.....(_____) 53
54. Uric acid and other nitrogen compounds are removed from the human body by means of the.....(_____) 54
55. Animals are unable to manufacture food in their bodies as plants do, because they lack.....(_____) 55
56. The gradual or the sudden change of plants or animals through successive generations is known as.....(_____) 56
57. The middle fin-like organ of the last segment of the abdomen of the crayfish is named the.....(_____) 57
58. A characteristic that arises during individual life as a result of environmental influences is said to be.....(_____) 58
59. Excretion in the body of the earthworm takes place principally through a large number of small tubular organs found throughout their bodies. These organs are named.....(_____) 59
60. Adrenals are ductless glands situated near the.....(_____) 60

Number right.....(Score, Part I)

PART II

DIRECTIONS. Each of the following questions is followed by five alternative answers, of which only **one** is correct. Select the one that is correct and put its number in the parentheses at the right, as shown in the sample.

SAMPLE.

a. An animal useful to man is the—
1 San Jose scale 2 Hessian fly 3 tent caterpillar 4 tussock moth 5 ladybird beetle.....(**5**)

---

1. The number of main divisions of the body of an insect are—
1 2 2 1 3 3 4 6 5 4.....( ) 1
2. A good example of a crustacean is the—
1 oyster 2 starfish 3 slug 4 crayfish 5 hydra....( ) 2
3. The earthworm moves by means of—
1 pseudopodia 2 setae 3 tube feet 4 cilia 5 flagella..( ) 3

4. An example of an animal that has ten legs is the—
1 butterfly 2 earthworm 3 lobster 4 locust 5 starfish.....( ) 4

5. The third pair of legs of the grasshopper is attached to the—
1 mesothorax 2 abdomen 3 prothorax 4 metathorax 5 cephalothorax.....( ) 5

6. An animal that molts in order to increase in size is the—
1 fish 2 crayfish 3 frog 4 earthworm 5 bird....( ) 6

7. Breathing in mammals is accomplished by—
1 lungs 2 the body wall 3 spiracles 4 book lungs 5 gills.....( ) 7

8. Digested foods enter the blood stream by a process called—
1 assimilation 2 excretion 3 circulation 4 absorption 5 respiration.....( ) 8

9. An animal that possesses ovipositors is the—
1 potato beetle 2 crab 3 oyster 4 earthworm 5 grasshopper.....( ) 9

10. The process of converting an insoluble food into a soluble form is called—
1 digestion 2 osmosis 3 assimilation 4 metabolism 5 absorption.....( ) 10

11. An insect harmful to vegetation is the—
1 cockroach 2 cutworm 3 mosquito 4 flea 5 blowfly.( ) 11

12. The number of legs found on the bodies of spiders is—
1 8 2 4 3 10 4 2 5 6.....( ) 12

13. The membrane covering the gills of crayfishes is called the—
1 ventricle 2 ostium 3 carapace 4 operculum 5 rostrum.....( ) 13

14. The anopheles mosquito is known to spread germs that cause—
1 yellow fever 2 typhoid 3 diphtheria 4 malaria 5 measles.....( ) 14

15. The law of heredity was discovered by—
1 Aristotle 2 Lister 3 Burbank 4 Audubon 5 Mendel.( ) 15

16. The most numerous class of animals is the—
1 crustaceans 2 amphibians 3 insects 4 birds 5 reptiles.....( ) 16

17. An animal having a cephalothorax is the—
1 frog 2 lizard 3 crayfish 4 butterfly 5 bird....( ) 17

18. The wiggler stage of the mosquito is also known as the—
1 pupa 2 tadpole 3 imago 4 polliwog 5 larva....( ) 18

19. Animals that feed on plants are said to be—
1 social 2 herbivorous 3 omnivorous 4 carnivorous 5 gregarious.....( ) 19
20. The bone of the upper leg is called the—
1 tibia 2 ulna 3 humerus 4 patella 5 femur....( ) 20
21. The natural moisture in the mouth is called—
1 pepsin 2 saliva 3 lipase 4 rennin 5 gastric juice....( ) 21
22. One of the ruminants is the—
1 dog 2 rabbit 3 cow 4 monkey 5 horse....( ) 22
23. A good example of an animal having compound eyes is the—
1 hydra 2 crayfish 3 starfish 4 tapeworm 5 shark....( ) 23
24. The offspring resulting from a cross between a horse and a donkey is called—
1 mule 2 Shetland pony 3 zebra 4 horse 5 caribou..( ) 24
25. The greater part of absorption in the alimentary canal of man takes place in the—
1 liver 2 oesophagus 3 pancreas 4 stomach 5 intestines.....( ) 25
26. The larvæ of the codl ng moth are a serious enemy of—
1 apples 2 peaches 3 tomatoes 4 plum trees 5 dahlias( ) 26
27. Germs that cause tuberculosis were discovered by—
1 Pasteur 2 Koch 3 Harvey 4 Mayo 5 Jordan....( ) 27
28. Animals which eat flesh only are called—
1 rodentia 2 herbivora 3 omnivora 4 carnivora 5 ungulata.....( ) 28
29. The coloring pigment of the eye is found in the—
1 cornea 2pupil 3 lens 4 retina 5 iris.....( ) 29
30. Animals that eat refuse or waste are called—
1 rodents 2 scavengers 3 ruminants 4 herbivora 5 carnivora.....( ) 30
31. The recognized founder of zoology was—
1 Harvey 2 Pliny 3 Aristotle 4 Pasteur 5 Galen....( ) 31
32. "Spawning" is a term applied to the egg-laying activity of—
1 fishes 2 turtles 3 toads 4 lizards 5 dragon flies....( ) 32
33. The majority of all animals move from place to place by means of—
1 wings 2 legs 3 cilia 4 feathers 5 fins.....( ) 33
34. Ganglia are tissues that work in connection with the—
1 stomach 2 large intestine 3 lungs 4 nervous system 5 blood vessels.....( ) 34
35. Large scales found on the under surface of the snake are called—
1 somites 2 peels 3 scabs 4 flakes 5 scutes....( ) 35

36. The cause of tuberculosis is—
1 overwork 2 cramped lungs 3 loss of sleep 4 a bacillus 5 hereditary weakness.....( ) 36

37. Insects that have hard outer (anterior) wings called elytra are the—
1 houseflies 2 katydids 3 grasshoppers 4 dragon flies 5 beetles.....( ) 37

38. An animal that discharges some of its waste by means of a large number of nephridia is the—
1 earthworm 2 starfish 3 liver fluke 4 locust 5 toad..( ) 38

39. An apiary is a—
1 bee colony 2 insect trap 3 insecticide 4 fish hatchery 5 poultry incubator.....( ) 39

40. A poisonous lizard found in the United States is the—
1 salamander 2 garter snake 3 chameleon 4 Gila monster 5 horned toad.....( ) 40

Number right.....(Score, Part II)

Since Test 1 is designed for plant biology, either Form A or Form B may be used alone, or both forms can be given and the results averaged. Similarly, the same procedure for Test 2, which is designed for animal and human biology, can be followed.

Both complete tests are to be administered in exactly the same way and thirty-two minutes of actual working time is allowed for each.

Directions for Administering

The directions for giving Test 1 and Test 2 (either Form A or Form B) are the same. Each form of the two tests is composed of two parts, designated as Part I and Part II.

When the test is to be given see that the desks are cleared and that each pupil has at least two sharpened pencils. Have a supply of pencils on hand in case of need. When the desks are cleared and the pupils are ready, say to the class: "**We are going to have a biology test. I will give each of you a copy of this booklet. Do not open it or write anything on it until you are told to do so.**" Distribute the booklets.

When the booklets are placed on desks, face up, say: **"Now write your name, age, class and other information called for on the front page."** After the pupils have had time enough to fill in the information, say: **"I will read aloud the directions on the front page while you read them to yourselves."** Read the instructions. After the last sentence is read (**"ask no questions after the examination has begun"**), say to the class: **"When I say 'BEGIN', turn to Part I, read the directions carefully, and start. Work as rapidly as you can, but do not hurry. If you do not understand the directions read them again. You will be allowed 20 minutes to answer the 60 questions. If you finish Part I before the time is up, look over your work to see that you have omitted no questions and correct any mistakes you may have made."** Make a note of the time, minutes and seconds, then say: **"BEGIN."**

At the end of 20 minutes, say: **"STOP! TURN TO PART II. Read the directions carefully. You are allowed 12 minutes to answer the 40 questions. BEGIN."** Make a note of the time, minutes and seconds, as soon as you have finished this sentence.

At the end of 12 minutes say: **"STOP! CLOSE YOUR BOOKLETS."** Then have all the booklets collected immediately.

While the test is in progress, the examiner should walk about the room making sure—

a. that the pupils are paying attention to their work.
b. that they are writing their answers on the lines for the answers in Part I and that they are answering the questions in the proper manner in Part II.
c. that they do not stop work at the end of the first or second page of either part before the time for the part is up.

No questions are to be asked or answered while the test is in progress.

Directions for Scoring

The correct answers to the 100 items of both forms of Test 1 and of Test 2 are given in answer keys which have been prepared for each form (see Tables XXI, XXII, XXIII, and XXIV). To score the test, place the key so that the answers are opposite

to the corresponding responses given on the test. In order to facilitate the scoring of the tests, the key should be folded or cut into strips along the heavy lines after the answers.

The tests are entirely objective in scoring and by use of the following keys a clerk or reliable student may score the tests. However, it is recommended that biology teachers mark their own papers in order to aid them in utilizing to the fullest extent the results of the tests.

In scoring the papers, it is recommended that a check mark (√) be placed in the right margin opposite each correct response.

All items have the same value. The pupil's score is the total number of correct responses. The highest possible score on Test 1, Form A, for example, is 100. Part I of this test is composed of 60 items, and Part II of 40. The two forms of each test are identical in construction. No partial credits are given.

When the parts of each form, Test 1 or Test 2, have been corrected and the number of right responses counted, write the scores on the blanks provided at the end of each part , and carry forward all scores to the title page of the booklet, where a summary blank is provided. Add the scores from the two parts of each of the tests to get the total score.

TABLE XXI

ANSWERS TO TEST 1, FORM A

KEY: TEST 1, FORM A

DIRECTIONS

Before using the key, fold and crease it both forward and backward on each of the lines between columns of answers.

To score the test booklet, begin with the key folded on the crease between the columns for pages 2 and 3. Let the column of answers for page 2 be up. Bring the column of answers for page 2 up to the responses on page 2 of the student's test paper, and compare.

Use a colored pencil and draw a heavy line opposite each right answer. Continue with page 3 by exposing the column of answers to page 3, and so on.

The score is the number of correct answers.

In Part I the pupil's answer may receive credit if it is not in the key only if it is *unquestionably* the exact equivalent of the answer in the key, or is given as correct in the textbook used by the pupil. The pupil should not be penalized for errors in spelling or grammar if his answer is otherwise correct and shows that he knows the answer to the question. The parts of answers given in brackets are correct but need not be given in the pupil's answer.

Copy the scores for the two parts of the test on to the first page of the booklet.

To insure accuracy, all scoring, counting, and copying should be checked.

Users of the test are requested to report to the publishers any corrections that should be made in the key or in the test.

PART I	
1.	cell
2.	compound
3.	green
4.	water, moisture
5.	dicotyledons[ous]
6.	iodine
7.	root hairs
8.	blade
9.	endosperm
10.	tissue
11.	osmosis
12.	leaves
13.	nitrogen
14.	carbon dioxide / CO_2
15.	cotton
16.	pollen
17.	plumule
18.	annular rings (*no credit for rings alone*)
19.	pollination

PART I	
20.	carbon dioxide / CO_2
21.	calyx
22.	seeds
23.	irrigation / water[ing]
24.	fruit
25.	oxidation / burning / combustion
26.	hilum
27.	flax seeds
28.	hypocotyl
29.	biennials
30.	proteins
31.	sugar cane / cane
32.	nitrogen
33.	oxygen
34.	symbiosis
35.	transpiration
36.	seed
37.	modified
38.	Burbank
39.	cambium
40.	wind
41.	parasite

PART I		PART II	PART II	PART II
42.	mode		14. (5)	31. (4)
43.	man, men		15. (4)	32. (5)
44.	sepals	PART II	16. (2)	33. (1)
45.	parallel		17. (2)	34. (1)
46.	micropyle	1. (1)	18. (4)	35. (3)
47.	pomes	2. (4)	19. (4)	36. (3)
48.	wood	3. (3)	20. (2)	37. (5)
49.	perfect	4. (1)	21. (2)	38. (4)
50.	Pasteurization	5. (3)	22. (1)	39. (4)
51.	chlorophyll	6. (3)	23. (1)	40. (5)
52.	alcohol	7. (5)	24. (2)	
53.	humus	8. (2)	25. (2)	
54.	epidermis	9. (1)	26. (2)	
55.	alternate	10. (4)	27. (5)	
56.	spores	11. (1)	28. (5)	
57.	leaves	12. (5)	29. (3)	
58.	composite	13. (3)	30. (3)	
59.	style			
60.	vernation			

TABLE XXII

ANSWERS TO TEST 1, FORM B

KEY: TEST 1, FORM B

DIRECTIONS

Before using the key, fold and crease it both forward and backward on each of the lines between columns of answers.

To score the test booklet, begin with the key folded on the crease between the columns for pages 2 and 3. Let the column of answers for page 2 be up. Bring the column of answers for page 2 up to the responses on page 2 of the student's test paper, and compare.

Use a colored pencil and draw a heavy line opposite each right answer. Continue with page 3 by exposing the column of answers to page 3, and so on.

The score is the number of correct answers.

In Part I the pupil's answer may receive credit if it is not in the key only if it is *unquestionably* the exact equivalent of the answer in the key, or is given as correct in the textbook used by the pupil. The pupil should not be penalized for errors in spelling or grammar if his answer is otherwise correct and shows that he knows the answer to the question. The parts of answers given in brackets are correct but need not be given in the pupil's answer.

Copy the scores for the two parts of the test on to the first page of the booklet.

To insure accuracy, all scoring, counting, and copying should be checked.

Users of the test are requested to report to the publishers any corrections that should be made in the key or in the test.

PART I

1.	[the] seed[s]
2.	peanuts
3.	protoplasm
4.	blue
5.	green
6.	pistil[s]
7.	root
8.	protein
9.	cell
10.	bacteria
11.	organ
12.	needles
13.	lenticles
14.	anther
15.	[crop] rotation
16.	palmate
17.	petal
18.	weed
19.	leaves

PART I

20.	carbohydrate[s] (*no credit for* starch[es] *or* sugar[s])
21.	symbiosis
22.	root hairs
23.	castor bean
24.	annuals
25.	protein
26.	germination
27.	yeast
28.	pollen tube
29.	opium
30.	petiole
31.	grapes
32.	leaves
33.	food
34.	yeast
35.	ovary
36.	Mendel
37.	excretion
38.	photosynthesis
39.	pollen
40.	leaves
41.	polycotyledon

PART I		PART II	PART II	PART II
42.	stigma	1. (4)	14. (3)	30. (3)
43.	grafting	2. (5)	15. (3)	31. (4)
44.	mistletoe	3. (4)	16. (2)	32. (2)
45.	pollen	4. (3)	17. (1)	33. (5)
46.	yeast	5. (3)	18. (5)	34. (3)
47.	chlorophyll	6. (2)	19. (5)	35. (3)
48.	cuticle	7. (2)	20. (4)	36. (1)
49.	humus	8. (2)	21. (3)	37. (1)
50.	excurrent	9. (1)	22. (2)	38. (4)
51.	nicotine	10. (1)	23. (1)	39. (5)
52.	guard cells	11. (2)	24. (1)	40. (5)
53.	geotropism	12. (4)	25. (2)	
54.	pistillate	13. (1)	26. (4)	
55.	hybrid		27. (4)	
56.	cellulose		28. (5)	
57.	bacteria		29. (5)	
58.	xylem			
59.	ferns			
60.	dehiscent			

TABLE XXIII

Answers to Test 2, Form A

KEY: TEST 2, FORM A

Directions

Before using the key, fold and crease it both forward and backward on each of the lines between columns of answers.

To score the test booklet, begin with the key folded on the crease between the columns for pages 2 and 3. Let the column of answers for page 2 be up. Bring the column of answers for page 2 up to the responses on page 2 of the student's test paper, and compare.

Use a colored pencil and draw a heavy line opposite each right answer. Continue with page 3 by exposing the column of answers to page 3, and so on.

The score is the number of correct answers.

In Part I the pupil's answer may receive credit if it is not in the key only if it is *unquestionably* the exact equivalent of the answer in the key, or is given as correct in the textbook used by the pupil. The pupil should not be penalized for errors in spelling or grammar if his answer is otherwise correct and shows that he knows the answer to the question. The parts of answers given in brackets are correct but need not be given in the pupil's answer.

Copy the scores for the two parts of the test on to the first page of the booklet.

To insure accuracy, all scoring, counting, and copying should be checked.

Users of the test are requested to report to the publishers any corrections that should be made in the key or in the test.

PART I

1. touch[ing] / feel[ing]
2. carbon dioxide / CO_2
3. feathers (*no credit for* flying, wings, *or* singing)
4. worker
5. fins
6. oxygen
7. butterfly[ies] / lepidoptera / moth[s]
8. system
9. nectar
10. honey bee
11. two / 2
12. protein
13. arteries
14. birds
15. Pasteur
16. dermis
17. insects
18. scales

PART I

19. protoplasm
20. marrow
21. compound
22. pupa[l]
23. auricles
24. starch
25. frog / toad
26. bacteria
27. legs
28. vertebrata / vertebrate[s]
29. gills
30. Harvey
31. paramecium
32. lungs
33. skin / body wall / cuticle
34. capillaries
35. earthworm
36. talons
37. perspiration / sweating
38. setæ
39. [disease] germs / bacteria
40. optic nerve

PART I	PART II	PART II	PART II
41. protozoa	1. (3)	15. (3)	31. (4)
42. { skull / cranium	2. (4)	16. (2)	32. (5)
43. boll weevil	3. (2)	17. (1)	33. (1)
44. { four / 4	4. (5)	18. (2)	34. (5)
45. rat	5. (3)	19. (3)	35. (4)
46. corpuscles	6. (4)	20. (1)	36. (4)
47. Aristotle	7. (1)	21. (5)	37. (5)
48. { beetles / coleoptera	8. (5)	22. (4)	38. (2)
49. iris	9. (2)	23. (2)	39. (3)
50. { fur / wool	10. (3)	24. (3)	40. (4)
51. tube feet	11. (1)	25. (3)	
52. beaver	12. (1)	26. (2)	
53. { inherited / inherent / hereditary / innate	13. (5)	27. (4)	
54. immune	14. (5)	28. (1)	
55. fauna		29. (2)	
56. cilia		30. (1)	
57. bumble bee (*no credit for* bee, honey bee)			
58. mollusca			
59. green glands			
60. head			

TABLE XXIV

ANSWERS TO TEST 2, FORM B

KEY: TEST 2, FORM B

DIRECTIONS

Before using the key, fold and crease it both forward and backward on each of the lines between columns of answers.

To score the test booklet, begin with the key folded on the crease between the columns for pages 2 and 3. Let the column of answers for page 2 be up. Bring the column of answers for page 2 up to the responses on page 2 of the student's test paper, and compare.

Use a colored pencil and draw a heavy line opposite each right answer. Continue with page 3 by exposing the column of answers to page 3, and so on.

The score is the number of correct answers.

In Part I the pupil's answer may receive credit if it is not in the key only if it is *unquestionably* the exact equivalent of the answer in the key, or is given as correct in the textbook used by the pupil. The pupil should not be penalized for errors in spelling or grammar if his answer is otherwise correct and shows that he knows the answer to the question. The parts of answers given in brackets are correct but need not be given in the pupil's answer.

Copy the scores for the two parts of the test on to the first page of the booklet.

To insure accuracy, all scoring, counting, and copying should be checked.

Users of the test are requested to report to the publishers any corrections that should be made in the key or in the test.

PART I	
1.	cell[s]
2.	two / 2
3.	chrysalis
4.	vertebræ[as]
5.	consumption / tuberculosis
6.	spiracles
7.	culex
8.	segments / somites
9.	epidermis
10.	gills
11.	[complete] metamorphosis
12.	arthropoda
13.	earthworm
14.	proteins
15.	water
16.	wiggler
17.	[toxin] antitoxin
18.	consumption / tuberculosis / typhoid
19.	skin / body wall

PART I	
20.	incomplete
21.	veins
22.	physiology
23.	[honey] bee / ant[s]
24.	enamel
25.	abdomen
26.	red corpuscles / hæmoglobin
27.	compound
28.	swarm[ing]
29.	swimmerets
30.	day
31.	diaphragm
32.	amœba[e]
33.	chitin
34.	liver
35.	proboscis
36.	excretion
37.	parasite[s]
38.	plasma
39.	[simple] eye
40.	exo[-skeleton]
41.	metazoa

PART I		PART II	PART II	PART II
42.	retina		13. (3)	29. (5)
43.	sperms / spermatozoa		14. (4)	30. (2)
44.	fission / [cell] division / conjugation		15. (5)	31. (3)
45.	ligament[s]	1. (3)	16. (3)	32. (1)
46.	starfish	2. (4)	17. (3)	33. (2)
47.	toxins	3. (2)	18. (5)	34. (4)
48.	adenoids	4. (3)	19. (3)	35. (5)
49.	diptera	5. (4)	20. (5)	36. (4)
50.	smallpox	6. (2)	21. (2)	37. (5)
51.	sturgeon	7. (1)	22. (3)	38. (1)
52.	ganglion[a]	8. (4)	23. (2)	39. (1)
53.	aphid[s] / hemiptera	9. (5)	24. (1)	40. (4)
54.	kidney[s] / urine	10. (1)	25. (5)	
55.	chlorophyll	11. (2)	26. (1)	
56.	evolution	12. (1)	27. (2)	
57.	telson		28. (4)	
58.	acquired			
59.	nephridia			
60.	kidney[s] (*no credit for* spine, backbone)			

Directions for Recording Scores

Class Record Sheets have been prepared on which scores of 50 pupils may be entered for convenience in filing.

Enter in the spaces provided at the top of the Class Record the grade, name of teacher, test used, school and other information called for.

The test papers should be arranged in alphabetical order. In

the spaces provided on the Class Record, write the names of the pupils, ages, scores on the various parts of the test used, total score, percentile rank in class and teachers' marks. Percentile rank and teachers' marks are optional. The percentile rank may be found for each pupil by means of the Percentile Graph.

The distribution of scores for the class may be entered at the foot of page two of the Class Record. When the distribution of scores is completed, the median or mid-measure for a class is easily calculated.

CLASS RECORD

Grade.....Teacher.....Test used.....Form used.....

School.....Date of examination.....19....

City and state.....

Name	Age	Part I	Part II	Part III	Total Score	P. R.	Tch's Mark
Medians							

CLASS RECORD

Grade.....Teacher.....Test used.....Form used.....

School.....Date of examination.....19....

City and state.....

Name	Age	Part I	Part II	Part III	Total Score	P. R.	Tch's Mark

Scores	Distributing marks
120–124	
115–119	
110–114	
105–109	
100–104	
95–99	
90–94	
85–89	
80–84	
75–79	
70–74	
65–69	
60–64	
55–59	
50–54	
45–49	
40–44	
35–39	
30–34	
25–29	
20–24	
15–19	
10–14	
5–9	
0–4	
Total	

second column for each score opposite the interval within which the score falls.

Summary

1. Equivalent forms of tests 1 and 2 were constructed and the items were arranged in the order of difficulty to follow the so-called Normal Probability Curve.

2. The problem of determining the real difficulty of the items is based upon the assumption that abilities in biology as in any other subject are distributed in accordance with some known distribution and the relative difficulty of each item was discovered. The base line of the normal curve is divided into ten equal parts with a unit length of $.6\sigma$. Figure 1 indicates this distribution and the per cent of the entire area included in each group. The ength of the base line is 6σ.

3. The methods given by Rugg were applied to the results of the second try-out of the preliminary testing and Tables XVIII and XIX were constructed. These Tables show the per cent of pupils failing each test-item, the position of each item, on a percentage distribution from 0 to 100 transmuted into terms of σ values on a 6σ scale and the percentile score.

4. The percentage of items assigned to each of the ten groups was determined and the selection of the items for the final forms of the tests was based upon equal or approximately equal percentile scores.

5. Table XX shows the distribution of test-items for the various topics of biology used in the final forms.

6. The tests are reproduced in full with directions for administering, scoring, and the tabulation of scores.

V

General Results—Determination of Standards

In order that the tests may be of the greatest educational value it is necessary that standards or "norms" be determined. Naturally, these standards are determined on the basis of pupil performance.

The final forms of the tests were given at the end of the first term during the month of January, 1929. Test 1 was given to pupils who had completed the work in plant biology, while Test 2 was given to pupils who had completed the work in animal and human biology. The tests with directions for administering and scoring were sent to the biology teachers in 43 school systems with whom arrangements for the giving of the tests had been made previously by personal letters.[1] The list of instructions were mimeographed, but the tests, and the keys containing the correct answers were printed in order to facilitate accuracy and speed on the part of the pupils and accuracy and speed in scoring. The tests and directions for administering and scoring are presented in Chapter IV. The times allowed for administering the tests are as follows:

Test 1	Test 2
Part I.....20 minutes	Part I.....20 minutes
Part II.....12 minutes	Part II.....12 minutes

Reports from teachers who gave the tests indicate that the time allowed was adequate in every case. The time element, however, was arrived at through experimenting with the final forms of the tests in twelve biology classes before the tests were sent out by the writer. In addition, the teachers who gave the preliminary tests, second try-out, all recorded the time required. The information was valuable in determining the time element for the final test. The teachers who gave the tests were in-

[1] See Appendix VII for the list of cities in which the tests were given.

structed to give Form A to half of the pupils, followed with Form B, and to reverse this order with the other half of the pupils. This procedure was carried out for both Test 1 and for Test 2.

The tests in their final form were administered to 2115 pupils in 37 public secondary schools in 22 states. Of the 2115 pupils who took the tests, 1070 in 31 schools took Test 1, Forms A and B, and 1045 in 30 schools, took Test 2, Forms A and B. Both tests were given in 18 of the 37 schools in which the testing was done, however, only pupils who had completed the plant biology work took Test 1, and those who had completed the work of animal and human biology took Test 2. The schools selected represent cities of various sizes as follows: seven in cities of 100,000 population and over, eleven in 25,000 to 100,000 and nineteen in those of 25,000 and less. All of the tests were given to pupils in the tenth grade or second year of the high school. Only results of pupils taking both Forms A and B of either Test 1 or of Test 2 are used in this study.

In scoring the test-items each one was arbitrarily given a value of one since the distribution of items as shown in Chapter IV is based upon a percentile ranking according to a normal distribution. The pupil's score is the total number of correct responses. The highest possible score on Test 1, Form A, for example, is 100. Part I of this test is composed of 60 items, and Part II of 40. The two forms of each test are identical in construction.

Class Record sheets for tabulating the scores were sent out with the tests.[2] After the teachers giving the tests had corrected the papers and tabulated the scores, both completed tests and tabulations were returned to the writer. These test papers and tabulations were rechecked in order to locate the occurrence of any possible errors. The returned test papers indicated that the tests had been given according to directions and had been properly used by the pupils. Tests were sent to 43 schools and results were received from 37. In four schools, the tests reached the teachers too late to be given and in two the teachers did not return the papers. Results were not used from the

[2]See page 112 for copy of the class record sheet.

latter because it was considered advisable to use only the data based on papers which had been checked.

Tentative norms are based upon returns from 1070 pupils taking both Forms A and B of Test 1, and 1045 pupils taking Forms A and B of Test 2. The general results of the final testing are indicated in Tables XXV, XXVI, XXVII and XXVIII. An examination of these tables shows the test used and the number of pupils taking each form. First and third quartiles and median scores are calculated for the various parts of each form of the two tests together with their probable errors. It is of interest to note that there is a very close agreement between the results of Forms A and B of Test 1 and of Forms A and B of Test 2. For example, a comparison of the results of Tables XXV and XXVI shows that the difference between the median scores of Form A and Form B of Test 1 to be only 2.1. This small difference indicates that the degree of difficulty existing between Form A and Form B of Test 1 to be about the same and that either form may be used satisfactorily for testing purposes. Further, the results indicated in Tables XXVII and XXVIII for Test 2, Forms A and B, show a similar relation-

TABLE XXV

QUARTILES AND MEDIAN SCORES FOR 1070 PUPILS IN 31 SCHOOLS ON TEST 1, FORM A

	1ST QUARTILE	MEDIAN SCORES	3RD QUARTILE
Part I	16.6 ± .514	22.1 ± .227	30.6 ± .591
Part II	14.4 ± .367	19.7 ± .152	23.0 ± .337
Entire test	31.0 ± 1.032	41.8 ± .460	53.6 ± .900

TABLE XXVI

QUARTILES AND MEDIAN SCORES FOR 1070 PUPILS IN 31 SCHOOLS ON TEST 1, FORM B

	1ST QUARTILE	MEDIAN SCORES	3RD QUARTILE
Part I	16.7 ± .542	23.4 ± .140	30.3 ± .503
Part II	14.0 ± .400	20.5 ± .137	23.2 ± .379
Entire test	30.7 ± .991	43.9 ± .402	53.5 ± .691

TABLE XXVII

QUARTILES AND MEDIAN SCORES FOR 1045 PUPILS IN 30 SCHOOLS ON TEST 2, FORM A

	1ST QUARTILE	MEDIAN SCORES	3RD QUARTILE
Part I	22.3 ± .402	29.0 ± .224	36.5 ± .474
Part II	18.4 ± .204	23.5 ± .096	27.4 ± .182
Entire test	40.7 ± .428	52.5 ± .239	63.9 ± .337

TABLE XXVIII

QUARTILES AND MEDIAN SCORES FOR 1045 PUPILS IN 30 SCHOOLS ON TEST 2, FORM B

	1ST QUARTILE	MEDIAN SCORES	3RD QUARTILE,
Part I	22.1 ± .265	28.8 ± .144	36.0 ± .274
Part II	19.3 ± .222	24.4 ± .101	28.2 ± .212
Entire test	41.4 ± .381	53.2 ± .210	64.2 ± .403

ship to exist. It will be noted also that the interquartile range for Test 1, Forms A and B, is 22.6 and 22.8, respectively. The interquartile range for Test 2, Form A, is 23.2 and for form B, 22.8. The differences between the interquartile ranges are so small that it will again be noted that a close agreements exists between the two forms of each test.

Tables XXIX, XXX, XXXI, and XXXII indicate the results of Test 1 and Test 2 in large city, medium-sized city, and small city high schools. These tables show the number of cases for each form of the two tests, the quartiles, and median scores. These values are expressed for the entire tests and not for the various parts. It will be noted in these tables that the results for Form A and Form B of each test are relatively close. The median score made by the large city schools on Test 1, Form A, for example, is 48.9, while the median score on the same test for Form B is 48.7.

It is significant that the median scores on both Tests 1 and 2, Forms A and B, are higher for the large city high schools than they are for either the medium-sized city or the small

TABLE XXIX

QUARTILES AND MEDIAN SCORES FOR TEST 1, FORM A, DETERMINED FROM RESULTS OF HIGH SCHOOLS REPRESENTING CITIES OF VARIOUS SIZES

TYPE OF CITY*	NUMBER OF CASES	1ST QUARTILE	MEDIAN SCORES	3RD QUARTILE
Large.....	490	35.6 ± .502	48.9 ± .280	56.2 ± .417
Medium-sized..	317	31.5 ± .387	43.3 ± .277	51.5 ± .392
Small.....	263	28.9 ± .812	40.7 ± .282	49.3 ± .401

TABLE XXX

QUARTILES AND MEDIAN SCORES FOR TEST 1, FORM B, DETERMINED FROM RESULTS OF HIGH SCHOOLS REPRESENTING CITIES OF VARIOUS SIZES

TYPE OF CITY*	NUMBER OF CASES	1ST QUARTILE	MEDIAN SCORES	3RD QUARTILE
Large.....	490	35.1 ± .498	48.7 ± .283	56.3 ± .421
Medium-sized..	317	31.9 ± .394	43.4 ± .279	51.6 ± .389
Small.....	263	29.1 ± .764	40.5 ± .279	49.1 ± .411

* The data of Tables XXIX and XXX are based on 7 large cities, 9 medium-sized cities, and 15 small cities for Test 1, Forms A and B.

city high schools. Tables XXIX, XXX, XXXI, and XXXII show that the large city high schools are about nine points higher for the two forms of each test than the small city high schools and five points higher on all tests than the medium-sized city high schools. However, it will be noted in these tables that the differences in the interquartile ranges for both tests in the three types of schools do not exceed 2.5. This indicates that a close agreement exists between the two forms of each test.

Various percentile norms are indicated in Tables XXXIII and XXXIV for Forms A and B of Test 1 and for Forms A and B of Test 2. These results are based on the scores of 1070 pupils in classes on plant biology and the scores of 1045 pupils in classes on animal and human biology. Thirty-seven schools in twenty-two states are represented. These results are for four and one-half months of instruction in each plant biology and animal and human biology. Table XXXIII reads

TABLE XXXI

QUARTILES AND MEDIAN SCORES FOR TEST 2, FORM A, DETERMINED FROM RESULTS OF HIGH SCHOOLS REPRESENTING CITIES OF VARIOUS SIZES

TYPE OF CITY*	NUMBER OF CASES	1ST QUARTILE	MEDIAN SCORES	3RD QUARTILE
Large.....	506	49.2 ± .341	58.8 ± .327	68.9 ± .362
Medium-sized..	304	44.4 ± .327	52.6 ± .376	62.8 ± .352
Small.....	235	41.8 ± .349	49.6 ± .382	59.3 ± .368

TABLE XXXII

QUARTILES AND MEDIAN SCORES FOR TEST 2, FORM B, DETERMINED FROM RESULTS OF HIGH SCHOOLS REPRESENTING CITIES OF VARIOUS SIZES

TYPE OF CITY*	NUMBER OF CASES	1ST QUARTILE	MEDIAN SCORES	3RD QUARTILE
Large.....	506	48.6 ± .347	57.1 ± .317	67.7 ± .357
Medium-sized..	304	43.6 ± .330	52.1 ± .362	62.4 ± .361
Small.....	235	40.7 ± .351	48.3 ± .385	58.9 ± .371

* The data of Tables XXXI and XXXII are based on 7 large cities, 9 medium-sized cities, and 14 small cities for Test 2, Forms A and B.

as follows: Of the 1070 pupils who took Test 1, Form A, 10 per cent reach or exceed scores of 63.6, 20 per cent reach or exceed 57.3, and 80 per cent reach or exceed 27.4. The 50 percentile is the median score. Half of the pupils obtained scores equal to or higher than the median. Half of the pupils obtained scores equal to or lower than the median. The 75 percentile is the upper (or third) quartile. The 25 percentile is the lower (or first) quartile. One-fourth of the pupils obtained scores equal to or higher than the upper quartile. One-fourth of the pupils obtained scores equal to or lower than the lower quartile.

In order to compare the score of a pupil in a test with the scores of the class as a whole, or in the order to compare two or more classes, the most effective way is to draw a percen-

TABLE XXXIII

PERCENTILE NORMS FOR TEST 1

	FORM A		FORM B
10% of the pupils reach or exceed	63.6		62.6
20% of the pupils reach or exceed	57.3		56.4
25% of the pupils reach or exceed	53.6		53.5
30% of the pupils reach or exceed	51.9		52.0
40% of the pupils reach or exceed	47.8		48.1
50% of the pupils reach or exceed	41.8	(Median)	43.9
60% of the pupils reach or exceed	39.5		40.1
70% of the pupils reach or exceed	34.3		34.4
75% of the pupils reach or exceed	31.0		30.7
80% of the pupils reach or exceed	27.4		27.9
90% of the pupils reach or exceed	22.4		21.4

TABLE XXXIV

PERCENTILE NORMS FOR TEST 2

	FORM A		FORM B
10% of the pupils reach or exceed	71.4		70.3
20% of the pupils reach or exceed	65.4		66.5
25% of the pupils reach or exceed	63.9		64.2
30% of the pupils reach or exceed	61.2		59.3
40% of the pupils reach or exceed	57.3		55.3
50% of the pupils reach or exceed	52.5	(Median)	53.2
60% of the pupils reach or exceed	49.7		48.1
70% of the pupils reach or exceed	46.1		44.1
75% of the pupils reach or exceed	40.7		41.4
80% of the pupils reach or exceed	37.5		39.7
90% of the pupils reach or exceed	32.9		33.7

tile curve. The Universal Percentile Graph which has been designed by Otis may be used for this purpose. A detailed description of the Percentile Graph is given by Arthur S. Otis[3] in his "Statistical Method in Educational Measurement." This description of the percentile curve is given by Otis as follows: "A percentile curve shows not only the median score of a group of pupils which have been tested but also the range of variability of the scores. It shows at a glance just what per cent of the scores of the class is exceeded by the score of any given individual and just what per cent of the group attains or exceeds any given score. Two curves on the same graph show very clearly the amount of overlapping of the scores of different groups." The curves in Figures 2 represent distribution of scores made by 27 pupils in Test 1, Form A, and 47 pupils in

[3] Otis, Arthur S., *Statistical Method in Educational Measurement.* World Book Company, New York, 1925.

Test 1, Form B. "The point where the percentile curve cuts the 50-percentile line represents the median score of the group. The value so found may not be exactly the same as the median found in the usual way by counting the middle paper in order of score, but if not, the median score so found by means of the

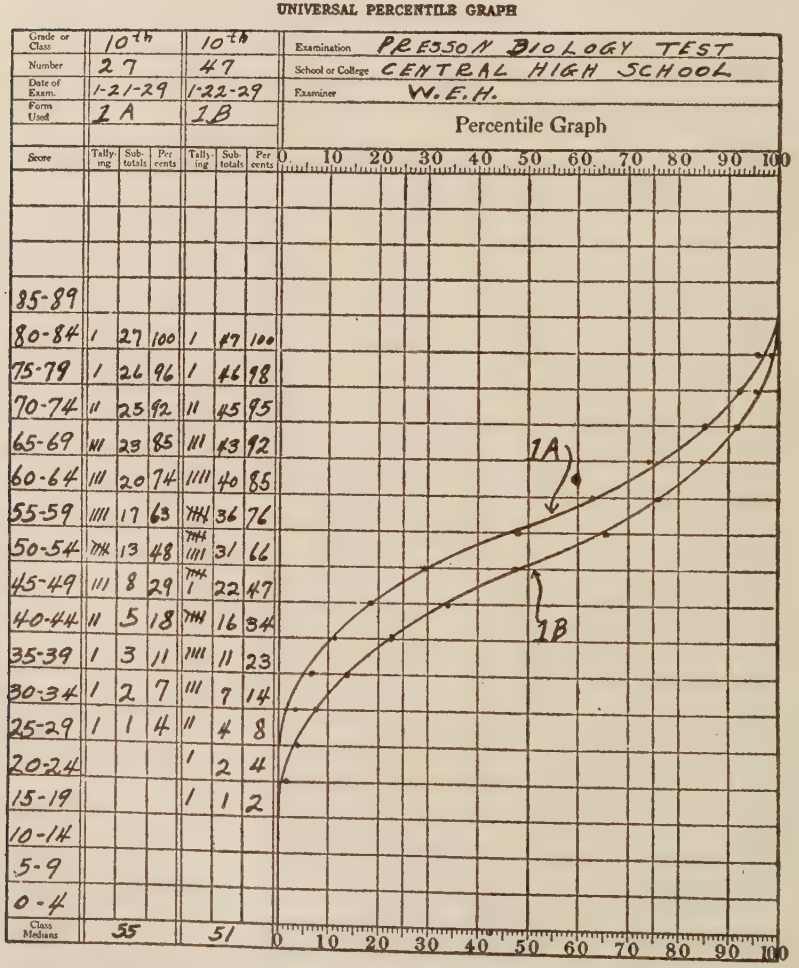

Figure 2.—Percentile curves representing the distributions of scores on Test 1, Forms A and B, of 27 and 47 pupils, respectively.

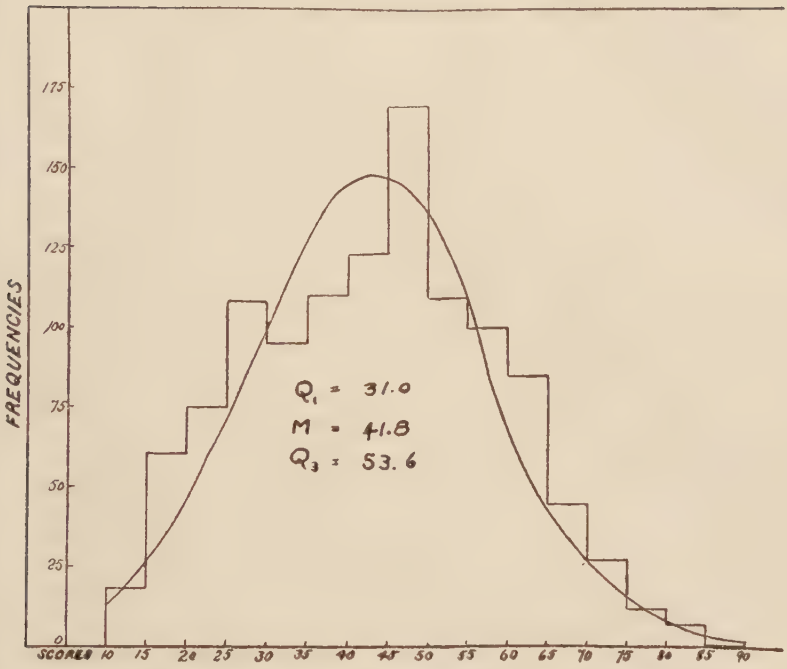

Figure 3.—Histogram showing distribution of scores on Test 1, Form A together with the corresponding normal probability curve.

curve is considered to represent the distribution better and to be in that sense more nearly accurate." In Figure 2, the median scores for the two groups on Test 1, Forms A and B, are respectively 55 and 51.

The points at which the curve cuts the 25- and 75-percentile lines represent the lower and upper scores of a distribution. The interval between these is the interquartile range. This is a very convenient measure of the scatter of the distribution. In Figure 2 the interquartile range for Test 1, Forms A and B, are respectively 17.00 and 19.00. Directions for plotting curves and their use accompany each graph and those who wish a more thorough understanding of the meaning and use of the percentile graph are referred to *Statistical Method in Educational Measurement*, by Arthur S. Otis.

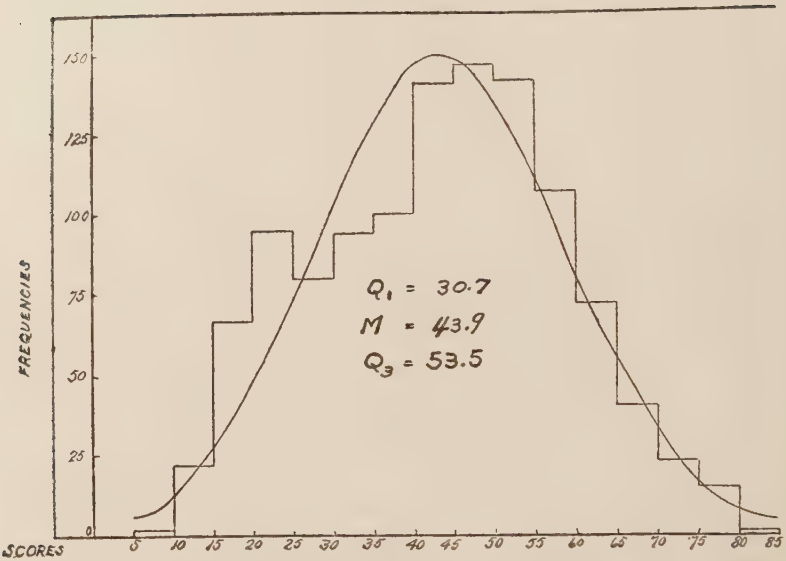

Figure 4.—Histogram showing distribution of scores on Test 1, Form B together with the corresponding normal probability curve.

The frequency distribution of 1070 scores obtained on Test 1, Forms A and B, are shown in Figures 3, and 4. Figures 5 and 6 show the distribution of 1045 scores obtained in Test 2, Forms A and B. These figures also show the corresponding normal probability curves. An examination of these figures indicates a close agreement between the form of the actual distribution and the theoretical curve. This would indicate that the distributions are quite stable and that the pupils who took these tests give a measure of what would be expected if the number taking them had been increased indefinitely. An analysis of the curves further indicates the reliability of the tests.

By the reliability of a test is meant the degree to which the scores of the test are consistent in measuring whatever the test measures. Reliability coefficients are determined by means of correlating different forms of the same test which have been applied to the same pupils. The coefficients show the correlation between the sets of scores on Form A and Form B of Test 1,

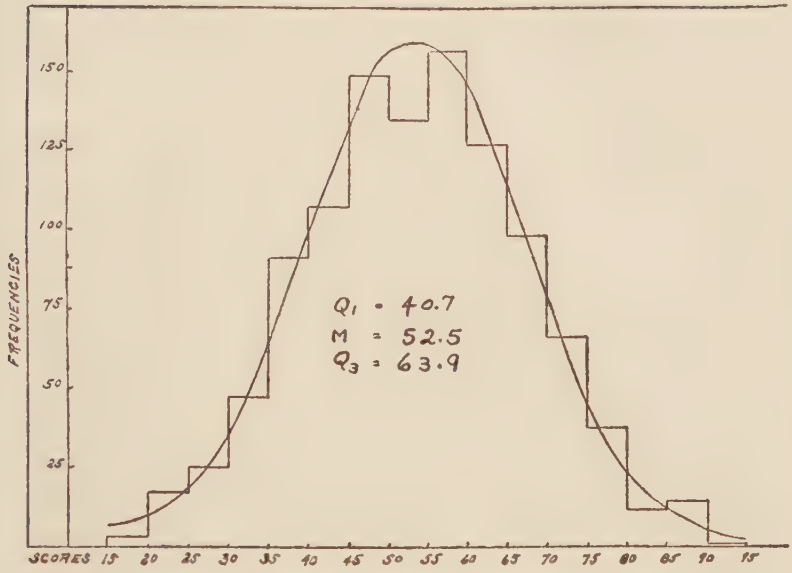

Figure 5.—Histogram showing distribution of scores on Test 2, Form A, together with the corresponding normal probability curve.

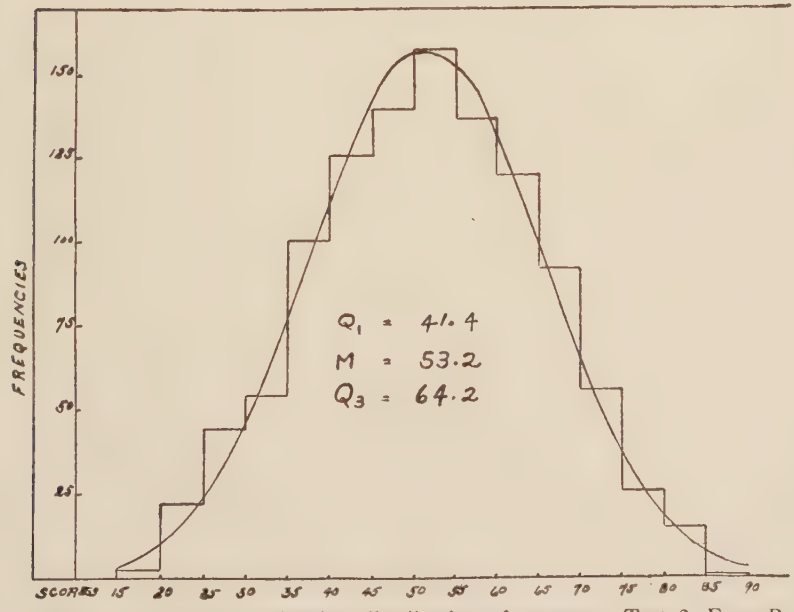

Figure 6.—Histogram showing distribution of scores on Test 2, Form B, together with the corresponding normal probability curve.

and on Form A and Form B of Test 2. The Pearson Product-Moment Formula is used for the determinations

$$r_{12} = \frac{\Sigma x y}{N \sigma_x \sigma_y}.$$

Tables XXXV and XXXVI give the reliability coefficients for Test 1 and Test 2 and for their respective parts.

The coefficients of Test 1 are based upon returns from 31 schools in 18 states, while those of Test 2 are based upon returns from 30 schools in 17 states. Large city, medium-sized city, and small city high schools are represented. The reliability coefficients indicated in Table XXXV for Test 1, Parts I and II, and the entire test are, respectively, r = .91, r = .86, and r = .90. Similarly, the reliability coefficients indicated in Table

TABLE XXXV

RELIABILITY COEFFICIENTS FOR TEST 1, FORM A WITH FORM B, DETERMINED FROM RETURNS OF 31 SCHOOLS

	NUMBER OF CASES	RELIABILITY COEFFICIENTS
Part I	1070	.91 ± .004
Part II	1070	.86 ± .005
Entire test	1070	.90 ± .004

TABLE XXXVI

RELIABILITY COEFFICIENTS FOR TEST 2, FORM A WITH FORM B, DETERMINED FROM RETURNS OF 30 SCHOOLS

	NUMBER OF CASES	RELIABILITY COEFFICIENTS
Part I	1045	.89 ± .004
Part II	1045	.84 ± .006
Entire test	1045	.88 ± .005

XXXVI for Test 2, Parts I and II, and the entire test are, respectively, r = .89, r = 84, and r = .88.

These reliability coefficients again indicate that the relative differences between the two forms of both tests are exceedingly small. Either form of the tests may be used and the results obtained will be, on the basis of the above data, the same. It is interesting to note that the tests as a whole show a greater reliability than the individual parts. This is due to the fact that there is an averaging of abilities of the whole group when both the simple recall and multiple responses type of items are used.

Table XXXVII indicates reliability coefficients for Test 1 and for Test 2 based upon returns from schools and cities of various sizes ranging from 100,000 population and over to 25,000 population and under. These coefficients are expressed for the test as a whole and not for the individual parts.

TABLE XXXVII

RELIABILITY COEFFICIENTS FOR TEST 1 AND TEST 2 DETERMINED FROM RETURNS OF SCHOOLS REPRESENTING CITIES OF VARIOUS SIZES

TEST 1 FORM A WITH FORM B			TEST 2 FORM A WITH FORM B		
HIGH SCHOOLS	NO. OF CASES	ENTIRE TEST	HIGH SCHOOLS	NO. OF CASES	ENTIRE TEST
Large city (7).....	490	.91 ± .005	Large city (7).....	506	.90 ± .005
Medium-sized (9) city.....	317	.86 ± .009	Medium-sized (9) city.....	304	.87 ± .008
Small city (15).....	263	.81 ± .012	Small city (14).....	235	.82 ± .014

The coefficients indicated in Table XXXVII are based upon results of 1070 pupils on Test 1, Forms A and B, and 1045 pupils on Test 2, Forms A and B. Test 1 was administered in 31 schools and Test 2 in 30. Only seven large city schools for each test were selected, but the number of pupils in these schools who took the tests exceeded those of either the medium-sized city or small city high schools. It will be noted that the reliability coefficients for the large city high schools are about

.05 higher for the two tests than they are for the medium-sized city and .10 for the small city high schools, while the medium-sized city schools average about .05 higher than the small city schools. It is evident from these results that there are more consistent conditions of instruction in biology in large city schools than there is found in either the medium-sized city or the small city high schools.

The probable error of a score for Test 1 and for Test 2 was computed from the correlations of Tables XXXV and XXXVI. The values are obtained by means of the formula

$$\text{P.E.}_{(\text{Score})} = .6745 \quad \frac{\sigma_1 + \sigma_2}{2} \sqrt{1 - r_{12}}.$$

The value of r_{12} for Test 1 is .90 and for Test 2, .88. The values of P. E. (Score) for Test 1 and Test 2 are, respectively, 3.32 and 3.11. This means that the chances are even that the true score of a pupil in Test 1 will not be in error by more than 3 points and for Test 2 more than 3 points and that the chances are about ten to one that the error in either test will not be more than twice the errors given above. These results indicate that the tests furnish a reliable measure of pupil ability to perform the tasks of biology as measured by these tests.

Of the criteria set up in Chapter II, in an effort to make the test valid, two are used in connection with the results of the final testing. These are correlations with school marks and correlations with a standardized test in the same field.[4] These

TABLE XXXVIII

CORRELATIONS BETWEEN TEST SCORES AND TEACHERS' MARKS FOR TEST 1

	FORM A			FORM B		
CASES	PART I	PART II	ENTIRE TEST	PART I	PART II	ENTIRE TEST
483	.54 ± .021	.60 ± .019	.71 ± .016	.56 ± .020	.64 ± .017	.73 ± .015

[4] The Ruch-Cossman Biology Test, Forms A and B, was used for this purpose.

coefficients of correlations are shown in Tables XXXVIII, XXXIX, XL and XLI, The validity coefficients of Table XXXVIII are found by correlating teachers' marks for 483 pupils with the scores of the same pupils on Test 1, Forms A and B[5]. The coefficients for Form A, Part I, Part II, and the entire test are, respectively, r = .54, r = .60, and r = .71, and for Form B, Part I, Part II, and the entire test, r = .56, r = .64, and r = .73.

TABLE XXXIX

CORRELATIONS BETWEEN TEST SCORES AND TEACHERS' MARKS FOR TEST 2

	FORM A			FORM B		
CASES	PART I	PART II	ENTIRE TEST	PART I	PART II	ENTIRE TEST
504	.59 ± .018	.65 ± .017	.75 ± .014	.58 ± .020	.66 ± .017	.74 ± .013

Table XXXIX shows that Teachers' marks for 504 pupils were correlated with scores on Test 2, Forms A and B.[6] The coefficients for Form A, Part I, Part II, and the entire test are, respectively, r = .59, r = .65, and r = .75, and for Form B, Part I, Part II, and the entire test, r = .58, r = .66, and r = .74.

These results show that the tests should be valuable in determining the abilities of pupils in biology courses that include work similar to the content that was analyzed as a foundation for these tests.

TABLE XL

CORRELATIONS BETWEEN TEST SCORES ON TEST 1 AND THE RUCH-COSSMAN BIOLOGY TEST, FORM A

NUMBER OF CASES	FORM A	FORM B
214	.79 ± .015	.78 ± .019

[5] See Appendix VIII for list of schools from which teachers' marks and test scores were obtained on Test 1, Forms A and B.

[6] See Appendix IX for list of schools from which teachers' marks and test scores were obtained on Test 2, Forms A and B.

TABLE XLI

CORRELATIONS BETWEEN TEST SCORES ON TEST 2 AND THE RUCH-COSSMANN BIOLOGY TEST, FORM B

NUMBER OF CASES	FORM A	FORM B
196	.82 ± .015	.83 ± .012

The validity coefficients of Tables XL and XLI are based upon 214 cases for Test 1 and 196 for Test 2 with the Ruch-Cossman Biology Test.[7] The coefficients for Test 1, Forms A and B are, respectively, r = .79 and r = .78, and for Test 2, Forms A and B, r = .82 and r = .83.

The tests correlate highly both with teachers' marks and with an accepted measure in the same field. These high correlations are additional evidence of the reliability of the tests and give indications of the values of the test scores. Further, the extent of agreement between measures by the tests and other measures is an indication of their usefulness.

SUMMARY

1. The tests in their final forms were administered at the end of the second term during the month of January, 1929, to 2115 pupils in 37 public secondary schools located in 22 states. Large city, medium-sized city, and small city high schools are represented. All the tests were given to pupils in the tenth grade or second year of the high school. Tentative norms are based upon the results of pupils taking both Forms A and B of Tests 1 and 2.

2. All tests were given, corrected, and results tabulated by teachers in the various schools. Completed tests and tabulations were returned to the writer and rechecked. The returned test papers indicated that the tests had been given according to directions and had been properly used by the pupils.

3. Standards or norms are based upon returns from 1070

[7] These determinations are based upon results obtained in schools of Baltimore and Philadelphia.

pupils taking both Forms A and B of Test 1, and 1045 pupils taking Forms A and B of Test 2. Tables XXV, XXVI, XXVII, and XXVIII represent the number of cases, quartiles, and median scores for Test 1 and Test 2. Quartiles and median scores are also determined for schools representing schools of various sizes. These results are shown in Tables XXIX, XXX, XXXI, and XXXII.

4. A comparison of scores of the tests with the Ruch-Cossman Biology Test, Forms A and B, and with teachers' marks, indicates that the scores in the tests constitute rather accurate standards of attainment.

VI

Summarized Conclusions

1. The analysis of textbooks, teachers' final examination questions, state department of education courses of study, and city courses of study indicated that the content of biology in the public secondary schools is arranged in the separate biological sciences, namely, plant biology and animal and human biology. (Chapter II, sections 1, and 2, and 4.)

2. The stress placed upon the various topics of biology in the tests is proportional to the stress they received as a result of the analyses of textbooks, teachers' final examination questions, College Entrance Examination Board questions, Board of Regents questions, and state and city courses of study, respectively, upon which the validity of the tests was established. (Chapter II, Sections 1, 2, 3 and 4; Chapter III, Section 1.)

3. The subject matter of the tests follow closely teaching practices, as evidenced by judgments of teachers supposedly competent in evaluating the items of which the tests are composed, and experimentation with pupils in order to secure a reaction on the original list of items. (Chapter III, Section 1.)

4. Reliability coefficients for the tests were found to be:

Test 1, Form A with Form B.....r = .90 ± .004
Test 2, Form A with Form B.....r = .88 ± .005

These high correlation results show that there is unusually close agreement in the results in Form A as compared with Form B in each of the tests. (Chapter V, page 126.)

5. Correlations between test scores and teachers' final term marks were:

Test 1

	Form A			Form B		
Cases	Part I	Part II	Entire Test	Part I	Part II	Entire Test
483	.54 ± .021	.60 ± .019	.71 ± .016	.56 ± .020	.64 ± .017	.73 ± .015

Test 2

Form A				Form B		
Cases	Part I	Part II	Entire Test	Part I	Part II	Entire Test
504	.59 ± .018	.65 ± .017	.75 ± .014	.58 ± .020	.66 ± .017	.74 ± .013

Correlations between scores on Test 1, Forms A and B, and scores obtained on the Ruch-Cossman Biology Test Form A were:

No. of Cases	Form A	Form B
214	.79 ± .015	.78 ± .017

Correlations between scores on Test 2, Forms A and B, and scores obtained on the Ruch-Cossman Biology Test Form B were:

No. of Cases	Form A	Form B
196	.82 ± .015	.83 ± .012

These correlations furnish evidence of the validity of the test scores.

(Chapter V, pp. 128-129-130.)

6. Tentative norms were found to be as follows:
(Based upon results from all schools)

TEST 1		TEST 2	
	MEDIANS		MEDIANS
Form A.....	41.8 ± .460	Form A.....	52.5 ± .239
Form B.....	43.9 ± .402	Form B.....	53.2 ± .210

Based upon results from schools representing cities of various sizes:

TEST 1

FORM A			FORM B		
TYPE OF CITY	CASES	MEDIANS	TYPE OF CITY	CASES	MEDIANS
Large (7).....	490	48.9 ± .280	Large (7)....	490	48.7 ± .283
Medium-sized (9).....	317	43.3 ± .277	Medium-sized (9).....	317	43.4 ± .279
Small (15)....	263	40.7 ± .282	Small (15)...	263	40.5 ± .279

TEST 2

FORM A			FORM B		
TYPE OF CITY	CASES	MEDIANS	TYPE OF CITY	CASES	MEDIANS
Large (7).....	506	58.8 ± .327	Large (7)....	506	57.1 ± .317
Medium-sized (9).....	304	52.6 ± .376	Medium-sized (9).....	304	52.1 ± .362
Small (14)....	235	49.6 ± .382	Small (14)...	235	48.3 ± .385

The difficulty existing between the two forms of Test 1 and the two forms of Test 2 are nearly the same as shown by the above data and, consequently, either may be used interchangeably for testing purposes. (Chapter V, pp. 117-126.)

APPENDICES

APPENDIX I

REPORTS OF HEADS OF STATE DEPARTMENTS OF EDUCATION, CITY SECONDARY SCHOOL PRINCIPALS, AND SECONDARY SCHOOL TEACHERS ON THE USE OF BIOLOGY TEXTBOOKS

STATES	HEADS OF STATE DEPARTMENT OF EDUCATION				CITY SCHOOL PRINCIPALS			BIOLOGY TEACHERS		
	Number reporting titles of textbooks in general use	Number reporting no uniformity in the use of textbooks	Number reporting "unable to answer"	Number not reporting	Number reporting titles of textbooks in general use	Number reporting "unable to answer"	Number not reporting	Number reporting titles of textbooks used	Number reporting Biology not taught	Number not reporting
Alabama	1				2			2	1	3
Arizona		1			2			3		2
Arkansas	1				1		1	3		3
California	1				1		1	2		4
Colorado	1					1	1	4		2
Connecticut	1				2			3	1	2
Delaware	1				2			1		2
Florida	1				1	1		2	1	3
Georgia			1		2			2		4
Idaho	1					1	1	3	1	2
Illinois	1				1	1		4		2
Indiana	1				1		1	4		2
Iowa	1				1	1		2		4
Kansas	1				1		1	3		3
Kentucky	1				1	1		4		2
Louisiana	1		1		1	1		4	1	1
Maine	1				1	1		4		2
Maryland	1				2	1		4		2
Massachusetts	1				2			4	1	1
Minnesota		1			1		1	4		2
Mississippi	1					1	1	2		4
Missouri				1		1	1	5		1
Montana	1				2			4		2
Michigan	1				1	1		4		2
Nebraska	1					1	1	2		4
Nevada				1	2					2
New Hampshire				1	1	1		4		2

APPENDIX I—*Continued*

STATES	HEADS OF STATE DEPARTMENT OF EDUCATION				CITY SCHOOL PRINCIPALS			BIOLOGY TEACHERS		
	Number reporting titles of textbooks in general use	Number reporting no uniformity in the use of textbooks	Number reporting "unable to answer"	Number not reporting	Number reporting titles of textbooks in general use	Number reporting "unable to answer"	Number not reporting	Number reporting titles of textbooks used	Number reporting Biology not taught	Number not reporting
New Jersey				1		1	1	5		1
New Mexico			1		1		1	1		3
New York	1				1		1	5		1
North Carolina	1				2			3		3
North Dakota	1				2			2	1	3
Ohio		1			1	1		5		1
Oklahoma	1				2			4		2
Oregon	1				2			3		3
Pennsylvania			1		1	1		6		
Rhode Island			1		1	1		4	1	1
South Carolina	1				1		1	3		3
South Dakota		1			1		1	2		4
Tennessee	1				2			4		2
Texas	1				2			4	1	1
Utah	1				2					2
Vermont		1			2			4	1	1
Virginia	1				2			5		1
Washington	1					2		2		4
West Virginia				1		1	1	2		4
Wisconsin		1			2			3		3
Wyoming	1				1	1		4	1	1
Washington, D. C.					1					
Juneau, Alaska					1					
Total	32	6	5	5	61	21	16	152	11	111

APPENDIX II

DISTRIBUTION OF SETS OF EXAMINATION QUESTIONS RECEIVED FROM BIOLOGY TEACHERS THROUGHOUT THE UNITED STATES*

STATES	CITIES OF 100,000 POPULATION OR OVER	CITIES OF 25,000 TO 100,000 POPULATION	CITIES AND RURAL COMMUNITIES UNDER 25,000 POPULATION
Alabama	Birmingham		Florence Gadsden
Arizona			Miami
Arkansas			Hot Springs Van Buren
California	San Francisco Los Angeles	Bakerfield Alhambra Stockton	Santa Ana
Colorado	Denver		
Connecticut		Bristol Meredian New Britain Torrenton	Danbury
Florida		Miami Orlando St. Petersburg	West Palm Beach
Georgia	Atlanta		Valdosta Waycross Rome
Idaho			Idaho Falls
Illinois	Chicago	Bloomington Moline Bellville Elgin Evanston	
Indiana		Richmond Kokomo	
Iowa		Burlington	Boone Keokuk Muscatine
Kansas	Kansas City		Fort Scott Independence Lawrence
Kentucky			Ashland
Maine		Bangor	Rumford Augusta Auburn
Maryland	Baltimore		
Massachusetts	Boston Springfield	Brockton Malden	
Minnesota	Minneapolis		Rochester Evelth Albert Lea
Mississippi			Gulfport Columbus

APPENDIX II—*Continued*

STATES	CITIES OF 100,000 POPULATION OR OVER	CITIES OF 25,000 TO 100,000 POPULATION	CITIES AND RURAL COMMUNITIES UNDER 25,000 POPULATION
Missouri		Springfield	Hannibal
		Sedalia	
Michigan	Detroit	Battle Creek	
	Flint	Hamktrock	
	Kalamazoo	Jackson	
Montana			Miles City
			Missoula
			York
Nebraska			Beatrice
			Norfolk
			North Platte
			York
Nevada			Sparks
New Hampshire			Laconia
New Jersey	Jersey City	Irvington	
	Newark	Hoboken	
		New Brunswick	
New Mexico			Las Cruces
			Silver City
New York	Buffalo	Mt. Vernon	
	New York	Utica	
	Rochester		
	Syracuse		
North Carolina			Gastonia
			Greensboro
			High Point
North Dakota			Devils Lake
			Dickerson
			Minot City
			Valley City
Ohio	Akron	Hamilton	
	Cleveland	Lima	
	Columbus	Springfield	
Oklahoma			Altus
			Pitcher
Oregon			Ashland
			Medford
Pennsylvania	Philadelphia	Easton	Kingston
	Pittsburgh	Washington	
		York	
Rhode Island		Central Falls	
		Newport	
South Carolina			Sumpter
South Dakota			Huron
			Mitchell
			Watertown

APPENDIX II—*Continued*

STATES	CITIES OF 100,000 POPULATION OR OVER	CITIES OF 25,000 TO 100,000 POPULATION	CITIES AND RURAL COMMUNITIES UNDER 25,000 POPULATION
Tennessee			Clarksville Jackson
Texas	Dallas El Paso Fort Worth	Austin Waco	Paris
Vermont			Montpelier
Virginia	Norfolk Richmond	Petersburg	Lexington
Washington	Seattle	Bellington	Walla Walla Yakima
West Virginia		Charleston	Parkersburg
Wisconsin		Sheboygan Superior	Manitowoc
Wyoming			Red Springs
Total	31	46	65

Total number of cities represented.....142
Total number of states represented.....45

* Based upon 1920 census.

APPENDIX III

Cities in which the nineteen biology teachers who evaluated the original list of test-items were located:

Cities	Number of Teachers
Baltimore, Maryland	3
Jersey City, New Jersey	2
Lancaster, Pennsylvania	1
Newark, New Jersey	1
New York, New York	2
Norristown, Pennsylvania	1
Philadelphia, Pennsylvania	5
Phoenixville, Pennsylvania	1
Radnor, Pennsylvania	1
Richmond, Virginia	1
Wilmington, Delaware	1

APPENDIX IV

Instructions for Examiners Giving the Preliminary Tests (second try-out)

Test 1, Parts I and II, is designed to measure achievement of pupils in PLANT BIOLOGY, while Test 2, Parts I and II, is designed to measure achievement in ANIMAL AND HUMAN BIOLOGY. The directions are the same for the two tests.

1. Take two days for the tests. Those pupils who have just completed the work in *plant biology* will take Test 1, Part I, on the first day, and Part II on the next day. Follow the same procedure for those pupils who have just finished *animal and human biology* and give Test 2, Parts I and II. It is suggested that a double laboratory period be allowed for Part I of each test.

2. The time allowances given below must be followed:

Test 1, Part I.....90 minutes	Test 2, Part I.....90 minutes
Test 1, Part II.....40 minutes	Test 2, Part II.....40 minutes

3. When the test is to be given see that the desks are cleared and that each pupil has a sharpened pencil. Extra pencils on the teacher's desk will save the time of the pupils.

4. When the desks are cleared and the pupils are ready, say to the class, "We are going to have a biology test. I will give each of you a copy of this paper. Do not open it or write anything on it until you are told to do so." Distribute the papers.

5. After the papers have been distributed, face up, say, "Now write your name, age, class and other information called for on the front page. Do not turn this page until I tell you."

6. When the pupils have finished filling out the blanks, say, "Turn to the second page and I will read the directions aloud while you read them to yourselves." Read the instructions. After the directions and sample exercises have been explained, tell the pupils the time that is allowed for the test and say, "Ask no questions after you begin this test." Then say, "READY—GO." Make a note of the time, minutes and seconds.

7. At the end of the time allowed for the test say, "STOP! CLOSE YOUR PAPERS." Then have all papers collected immediately.

8. Do not score the papers.

9. Return all test papers to John M. Presson, Girard College, Philadelphia, Pa.

APPENDIX V

PERCENTILE SCORES ASSIGNED TO EACH TEST-ITEM WHICH CORRESPOND TO VARIOUS PERCENTAGES OF PUPILS WHO FAIL TO SOLVE ITEMS, BASED UPON AREA OF PROBABILITY CURVE ASSUMING THE BASE LINE TO BE BROKEN OFF AT $\pm 3\sigma$. (TEST 2, PART I—ANIMAL AND HUMAN BIOLOGY)

Item Number	Per Cent Failing	Distance x/σ	Percentile Score	Item Number	Per Cent Failing	Distance x/σ	Percentile Score	Item Number	Per Cent Failing	Distance x/σ	Percentile Score
1	.2	.29	4.83	51	32.4	2.55	42.50	101	64.2	3.36	56.00
2	.4	.45	7.50	52	33.2	2.57	42.83	102	65.2	3.29	56.50
3	.6	.56	9.33	53	33.8	2.59	43.17	103	66.4	3.42	57.00
4	1.4	.84	14.00	54	34.6	2.61	43.50	104	67.8	3.46	57.67
5	2.0	.98	16.33	55	35.4	2.63	43.83	105	68.8	3.49	58.17
6	2.2	1.02	17.00	56	36.0	2.65	44.17	106	69.8	3.52	58.67
7	2.6	1.08	18.00	57	36.6	2.66	44.33	107	71.0	3.55	59.17
8	3.4	1.20	20.00	58	37.4	2.68	44.67	108	71.8	3.57	59.50
9	4.6	1.33	22.17	59	38.4	2.71	45.17	109	72.8	3.60	60.00
10	5.4	1.41	23.50	60	39.2	2.73	45.50	110	73.6	3.63	60.50
11	5.8	1.44	24.00	61	40.2	2.76	46.00	111	74.6	3.66	61.00
12	6.4	1.49	24.83	62	40.8	2.77	46.17	112	75.4	3.69	61.50
13	7.2	1.55	25.83	63	41.6	2.79	46.50	113	76.0	3.70	61.67
14	7.2	1.55	25.83	64	42.0	2.80	46.67	114	76.8	3.73	62.17
15	8.2	1.62	27.00	65	42.8	2.82	47.00	115	77.2	3.75	62.50
16	8.8	1.66	27.66	66	42.8	2.82	47.00	116	77.8	3.76	62.67
17	9.4	1.69	28.17	67	43.4	2.84	47.33	117	78.8	3.79	63.17
18	9.8	1.72	28.69	68	44.2	2.86	47.67	118	79.4	3.82	63.67
19	10.4	1.75	29.27	69	45.0	2.88	48.00	119	79.4	3.82	63.67
20	11.4	1.81	30.17	70	45.6	2.90	48.33	120	80.2	3.85	64.17
21	12.2	1.85	30.83	71	46.0	2.91	48.67	121	81.0	3.88	64.67
22	13.0	1.88	31.33	72	46.6	2.92	48.83	122	81.8	3.90	65.00
23	13.8	1.92	32.00	73	47.2	2.94	49.00	123	82.4	3.93	65.50
24	14.4	1.94	32.33	74	47.8	2.95	49.17	124	83.4	3.97	66.17
25	15.2	1.98	33.00	75	48.6	2.97	49.50	125	84.2	4.00	66.67
26	15.8	2.00	33.33	76	49.0	2.98	49.67	126	84.8	4.02	67.00
27	16.6	2.04	34.00	77	49.6	2.99	49.83	127	85.8	4.06	67.67
28	17.4	2.07	34.50	78	50.2	3.01	50.17	128	86.4	4.09	68.17
29	18.2	2.10	35.00	79	50.8	3.02	50.33	129	86.4	4.09	68.17
30	19.2	2.14	35.67	80	51.6	3.04	50.67	130	87.4	4.14	69.00
31	19.8	2.16	36.00	81	52.0	3.05	50.83	131	88.4	4.19	69.83
32	20.6	2.19	36.50	82	52.4	3.06	51.00	132	88.8	4.21	70.17
33	21.0	2.20	36.67	83	52.8	3.07	51.17	133	89.4	4.25	70.83
34	21.4	2.22	37.00	84	53.6	3.09	51.50	134	89.4	4.25	70.83
35	21.4	2.22	37.00	85	54.2	3.10	51.67	135	90.0	4.28	71.33
36	22.4	2.25	37.50	86	54.8	3.11	51.87	136	90.8	4.32	72.00
37	23.4	2.28	38.00	87	54.8	3.11	51.87	137	91.8	4.38	73.00
38	24.2	2.30	38.33	88	55.2	3.12	52.00	138	92.6	4.44	74.00
39	24.8	2.32	38.67	89	55.8	3.13	52.17	139	93.6	4.51	75.17
40	25.6	2.35	39.17	90	56.6	3.16	52.67	140	94.4	4.58	76.33
41	26.2	2.37	39.50	91	57.2	3.18	53.00	141	95.6	4.70	78.33
42	27.2	2.40	40.00	92	57.6	3.19	53.17	142	96.4	4.68	79.67
43	27.8	2.42	40.33	93	58.4	3.21	53.50	143	97.0	4.87	81.33
44	27.8	2.42	40.33	94	59.0	3.23	53.87	144	97.8	4.99	83.17
45	28.4	2.44	40.67	95	59.8	3.24	54.00	145	98.4	5.11	85.17
46	29.0	2.46	41.00	96	60.4	3.26	54.33	146	98.4	5.11	85.17
47	29.6	2.47	41.17	97	61.0	3.28	54.67	147	98.8	5.22	87.00
48	30.2	2.49	41.67	98	61.8	3.29	54.83	148	99.4	5.44	90.67
49	31.0	2.51	41.83	99	62.4	3.31	55.17	149	99.6	5.55	92.50
50	31.6	2.52	42.17	100	63.2	3.32	55.33	150	99.6	5.55	92.50

APPENDIX VI

PERCENTILE SCORES ASSIGNED TO EACH TEST-ITEM WHICH CORRESPOND TO VARIOUS PERCENTAGES OF PUPILS WHO FAIL TO SOLVE ITEMS, BASED UPON AREA OF PROBABILITY CURVE ASSUMING THE BASE LINE TO BE BROKEN OFF AT $\pm 30\sigma$. (TEST 2, PART II—ANIMAL AND HUMAN BIOLOGY)

Item Number	Per Cent Failing	Distance x/σ	Percentile Score	Item Number	Per Cent Failing	Distance x/σ	Percentile Score	Item Number	Per Cent Failing	Distance x/σ	Percentile Score
1	.4	.45	7.50	34	32.4	2.55	42.50	67	65.8	3.40	56.67
2	.4	.45	7.50	35	33.2	2.57	42.83	68	67.0	3.44	57.33
3	1.4	.84	14.00	36	34.8	2.61	43.50	69	67.8	3.46	57.67
4	1.8	.94	15.67	37	36.0	2.65	44.17	70	68.6	3.48	58.00
5	2.6	1.98	18.00	38	37.4	2.68	44.67	71	69.8	3.52	58.67
6	3.0	1.14	19.00	39	38.8	2.72	45.33	72	70.8	3.54	59.00
7	4.4	1.31	21.83	40	40.2	2.76	46.00	73	72.2	3.59	59.83
8	5.6	1.43	23.83	41	41.4	2.77	46.17	74	73.2	3.62	60.33
9	6.1	1.47	24.50	42	42.4	2.81	46.83	75	74.0	3.64	60.67
10	7.4	1.56	26.00	43	43.8	2.84	47.33	76	75.0	3.67	61.17
11	8.2	1.62	27.00	44	44.8	2.87	47.83	77	75.8	3.70	61.67
12	9.8	1.72	28.67	45	45.4	2.89	48.17	78	77.2	3.74	62.33
13	10.8	1.77	29.50	46	46.6	2.92	48.67	79	78.4	3.78	63.00
14	11.8	1.82	30.33	47	47.6	2.94	49.00	80	79.8	3.83	63.83
15	12.6	1.87	31.17	48	48.8	2.97	49.50	81	81.2	3.88	64.67
16	13.8	1.92	32.00	49	49.6	2.98	49.67	82	81.2	3.88	64.67
17	13.8	1.92	32.00	50	50.6	3.01	50.17	83	82.6	3.94	65.67
18	15.0	1.97	32.83	51	51.2	3.03	50.50	84	83.8	3.98	66.33
19	16.2	2.02	33.67	52	52.2	3.05	50.83	85	85.2	4.04	67.33
20	17.4	2.07	34.50	53	53.0	3.08	51.17	86	86.4	4.09	68.17
21	18.8	2.12	35.33	54	53.6	3.09	51.33	87	88.0	4.17	69.50
22	20.0	2.17	36.17	55	54.6	3.11	51.83	88	89.2	4.23	70.50
23	21.4	2.22	37.00	56	55.4	3.13	52.17	89	90.4	4.30	71.67
24	22.6	2.25	37.50	57	56.0	3.15	52.50	90	91.8	4.38	73.00
25	23.6	2.29	38.17	58	56.8	3.17	52.83	91	92.8	4.45	74.17
26	24.6	2.32	38.67	59	57.4	3.19	53.17	92	92.8	4.45	74.17
27	25.4	2.34	39.00	60	58.4	3.21	53.50	93	94.0	4.55	75.83
28	26.4	2.38	39.67	61	59.2	3.23	53.83	94	95.2	4.65	77.50
29	27.4	2.41	40.17	62	60.2	3.26	54.33	95	96.4	4.69	79.83
30	28.2	2.43	40.33	63	60.2	3.26	54.33	96	97.6	4.96	82.67
31	29.6	2.47	41.17	64	61.8	3.28	54.83	97	98.6	5.16	86.00
32	30.8	2.50	41.83	65	63.4	3.34	55.67	98	99.4	5.44	90.67
33	31.8	2.53	42.17	66	64.8	3.38	56.33	99	99.8	5.71	95.17
								100	99.8	5.71	95.17

APPENDIX VII

Cities in which tests were administered, final try-out:

100,000 Population and over

Baltimore, Maryland
Buffalo, New York
Jersey City, New Jersey
Philadelphia, Pennsylvania (3 schools)
Richmond, Virginia

25,000 to 100,000 Population

Canton, Ohio
Chattanooga, Tennessee
Elkhart, Indiana
Jackson, Mississippi
Mobile, Alabama
Muskogee, Oklahoma
New London, Connecticut
Newport News, Virginia
Hazelton, Pennsylvania
Oshkosh, Wisconsin
Rutland, Vermont

25,000 Population and less

Albion, Michigan
Buford, Georgia
Carrollton, Georgia
Carrollton, Missouri
Catonsville, Maryland
Covington, Kentucky
Crystal Falls, Michigan
Darby, Pennsylvania
DeLand, Florida
Delaware, Ohio
Harriman, Tennessee
Jenkintown, Pennsylvania
Lansdowne, Pennsylvania
Lower Merion, Pennsylvania
Ludlow, Kentucky
Manchester, New Hampshire
Meredian, Mississippi
Troy, Alabama
Weston, West Virginia

APPENDIX VIII

Schools from which teachers' marks were obtained with test scores for Test 1, Forms A and B.

Schools	Number of Cases
Baltimore, Maryland	81
Buffalo, New York	89
Carrolton, Missouri	25
Elkhart, Indiana	59
Hazelton, Pennsylvania	26
Jackson, Mississippi	25
Ludlow, Kentucky	17
Philadelphia, Pennsylvania	65
Upper Darby, Pennsylvania	96

APPENDIX IX

Schools from which teachers' marks were obtained with test scores for Test 2, Forms A and B.

Schools	Number of Cases
Buffalo, New York	180
Carrolton, Georgia	12
Elkhart, Indiana	25
Hazelton, Pennsylvania	23
Philadelphia, Pennsylvania	82
Richmond, Virginia	86
Upper Darby, Pennsylvania	96

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Colorado
Idaho
Indiana
Kansas
Maryland
Missouri
New Jersey
New York
Oklahoma
Texas
Virginia
Washington
Wyoming

Cities

Albuquerque, N. M.
Ann Arbor, Mich.
Annapolis, Md.
Asheville, N. C.
Baltimore, Md.
Berkeley, Calif.
Biloxi, Miss.
Birmingham, Ala.
Bismarck, N. D.
Boston, Mass.
Boulder, Colo.
Brookline, Mass.
Chattanooga, Tenn.
Chicago, Ill.
Claremont, N. H.
Dallas, Texas
Denver, Colo.
Detroit, Mich.
Elkins, W. Va.
Fort Worth, Texas
Great Falls, Mont.
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Guthrie, Okla.
Harrisburg, Pa.
Hastings, Neb.
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Kansas City, Kans.
LaGrande, Ore.
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Nashville, Tenn.
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